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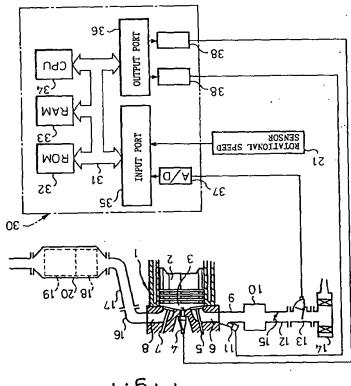
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EXHAUST GAS CLEANING APPARATUS FOR INTERNAL COMBUSTION ENGINES.

absorbent (19). from the SO_x absorbent (18), and NO_x from the NO_x from a lean state into a rich state, SOx is discharged bent (19). When the gaseous mixture is changed the SOx absorbent (18), and NOx in the NOx absora lean gaseous mixture is burnt, SO_x is absorbed in the upstream side of the NOx absorbent (19). When the interior of the exhaust gas passage which is on absorbed SOx when the air-fuel ratio of an entering entering exhaust gas is low, and discharging the (18) absorbing SO_x when the air-fuel ratio of an provided in an exhaust passage. An SOx absorbent centration of the entering exhaust gas is reduced is charge the absorbed NOx when the oxygen conratio of an entering exhaust gas is low, and disbent 19) sdapted to absorb NOx when the air-fuel (s) In an internal combustion engine, an NOx absor-



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caught by the sulfur trap is gradually increased. When the SO_x catching capability of the sulfur trap is saturated, the SO_x passes through the sulfur trap, and therefore there arises a problem in that the SO_x is absorbed into the NO_x absorbent and gradually accumulates in the NO_x absorbent.

DISCLOSURE OF THE INVENTION

An object of the present invention is to provide an exhaust purification device which can maintain a high NO_x absorption capability by the NO_x absorbent is used for a long time.

2Ox absorbent. rich when the SO_x should be released from the of the exhaust gas flowing into the SOx absorbent the SO_x absorbent lean and make the air-fuel ratio tain the air-fuel ratio of the exhaust gas flowing into flowing into the SOx absorbent to constantly mainwhich controls the air-fuel ratio of the exhaust gas is made rich; and an air-fuel ratio control means when the air-fuel ratio of the inflowing exhaust gas and, at the same time, releases the absorbed SO_x the air-fuel ratio of the inflowing exhaust gas is lean side of the NOx absorbent, absorbs the SOx when arranged in the exhaust passage on the upstream exhaust gas is lowered; an SOx absorbent which is when the oxygen concentration in the inflowing and, at the same time, releases the absorbed NO_x air-fuel ratio of the inflowing exhaust gas is lean, the exhaust passage, absorbs the NOx when the passage; an NOx absorbent which is arranged in nal combustion engine provided with an exhaust brovided an exhaust purification device of an inter-According to the present invention, there is

BRIEF DESCRIPTION OF THE DRAWINGS

embodiment of the internal combustion engine; Fig. Fig. 12 is an overall view showing further another chart for performing the NOx releasing processing; the internal combustion engine; Fig. 11 is a flow to themibodine tentions Ilits gniworks weiv listevo of the internal combustion engine; Fig. 10 is an 9 is an overall view showing another embodiment chart for calculating a fuel injection time TAU; Fig. showing an interruption routine; Fig. 8 is a flow timing of the NOx and SOx; Fig. 7 is a flow chart ing function; Fig. 6 is a view showing a releasing views for explaining an MOx absorption and releasdischarged from the engine; Figs. 5A and 5B are unburnt HC and CO and oxygen in an exhaust gas graph schematically showing a concentration of change of a correction coefficient K; Fig. 4 is a basic fuel injection time; Fig. 3 is a view showing a bustion engine; Fig. 2 is a view showing a map of a Figure 1 is an overall view of an internal com-

The present invention relates to an exhaust purification device of an internal combustion engine.

ВАСКЕВОЛИВ АВТ

plication No. 92920904.7). Application No. 08/066,100 or European Patent Apthe released NOx is reduced (refer to U.S. Patent made to release the NOx and, at the same time, temporarily made rich so that the NOx absorbent is inflowing exhaust gas to the NOx absorbent is NOx absorbent is saturated, the air-fuel ratio of the bent before the NOx absorption capability of the mixture is burned is absorbed by the NOx absorsage; the NOx generated when the lean air-fuel is lowered is arranged in an engine exhaust pasoxygen concentration in the inflowing exhaust gas is lean and releases the absorbed NOx when the when the air-fuel ratio of an inflowing exhaust gas engine an MOx absorbent which absorbs the MOx mixture is burned, in which internal combustion internal combustion engine in which a lean air-fuel The present applicant has already proposed an

into the NOx absorbent. sulfur trap, and therefore only the NOx is absorbed SOx discharged from the engine is caught by the 93112260.6). In this internal combustion engine, the 08/096,103 or European Patent Application No. sulfur trap (refer to U.S. Patent Application No. contained in the exhaust gas is caught by this stream side of the NO_x absorbent, and the SO_x vided in the engine exhaust passage at the upcombustion engine in which a sulfur trap is propresent applicant has already proposed an internal able to absorb almost any NOx. Therefore, the sud finally the NOx absorbent becomes no longer sorbed by the NOx absorbent is gradually lowered, creased, the amount of the NOx that can be abthe amount of SO_x in the NO_x absorbent is inabsorbent is gradually increased. However, when and accordingly the amount of SOx in the MOx exhaust gas to the NOx absorbent is made rich, absorbent even if the air-fuel ratio of the inflowing However, this SO_x is not released from the NO_x into the NO_x absorbent together with the NO_x. nal combustion engine, this SOx is also absorbed tained in the exhaust gas. Accordingly, in this interengine contain sulfur, and therefore SOx is con-However, the fuel and the lubrication oil of the

However, in this internal combustion engine, the SO_x caught by the sulfur trap is continuously being caught in the sulfur trap even if the air-fuel ratio of the exhaust gas flowing into the sulfur trap is made rich. Accordingly, the amount of the SO_x

13 is a view showing a releasing characteristic of

and the exhaust pipe 17 to a casing 20 accommodating an SO_x absorbent 18 and an NO_x absorbent 19 is arranged on the upstream side of the NO_x absorbent 19. In the embodiment shown in Fig. 1, the SO_x absorbent 18 and the NO_x absorbent 19 are integrally formed and the NO_x absorbent 19 are integrally formed and the NO_x absorbent 19 are integrally formed alumina.

An electronic control unit 30 comprises a digital computer and is provided with a ROM (read only remory) 32, a RAM (random access memory) 33, a CPU (microprocessor) 34, an input port 35, and an output port 36, which are mutually connected by a bidirectional bus 31. The air flow mater 13 generates an output voltage in proportion to the intake air amount, and this output voltage is thout to the intake air amount, and this output port 35. Also, a rotational speed sensor 21 generating an output pulse expressing the engine rotational speed is connected to the input port 35. On the output pulse expressing the input port 35. On the speed is connected to the input port 36 is connected via a small the fuel injector 11, respectively.

In the internal combustion engine shown in Fig. 1, the fuel injection time TAD is calculated based on for example the following equation:

 $A \cdot qT = UAT$

pecomes rich. smaller than the stoichiometric air-fuel ratio, that is, mixture fed into the engine cylinder becomes larger than 1.0, the air-fuel ratio of the air-fuel that is, becomes lean, while when K becomes comes larger than the stoichiometric air-fuel ratio, sir-fuel mixture fed into the engine cylinder be-K becomes smaller than 1.0, the air-fuel ratio of the stoichiometric air-fuel ratio. Contrary to this, when mixture fed into the engine cylinder becomes the the engine cylinder, and if K=1.0, the air-fuel ling the air-fuel ratio of the air-fuel mixture fed into correction coefficient K is a coefficient for controlspeed N) and the engine rotational speed N. The load Q/N (intake air amount Q/engine rotational map as shown in Fig. 2 as a function of the engine stored in advance in the ROM 32 in the form of a time TP is found in advance by experiments and stoichiometric air-fuel ratio. This basic fuel injection fuel mixture fed into the engine cylinder the necessary for making the air-fuel ratio of the airsic fuel injection time indicates a fuel injection time and K indicates the correction coefficient. The ba-Here, TP indicates the basic fuel injection time;

This correction coefficient K is controlled in accordance with the operating state of the engine. Figure 3 shows one embodiment of the correction coefficient K. In the embodiment shown in Fig. 3, during a warm-up operation, the correction Fig. 3, during a warm-up operation, the correction Fig. 3.

switch valve control; and Fig. 40 is a flow chart for TAU; Figs. 39A to 39D are flow charts of the flag is a flow chart for calculating the fuel injection time flow charts of the flag switch valve control; Fig. 38 the fuel injection time TAU; Figs. 37A to 37D are valve control, Fig. 36 is a flow chart for calculating Figs. 35A to 35D are flow charts of the flag switch chart for calculating the fuel injection time TAU; the exhaust gas temperature T; Fig. 34 is a flow valve control; Fig. 33 is a view showing the map of Figs. 32A to 32D are flow charts of a flag switch ratio of the NOx and SOx releasing control, etc.; is a timing chart showing the change of the air-fuel chart of the SOx and MOx releasing control; Fig. 31 SOx and NOx releasing control; Fig. 30 is a timing releasing control; Fig. 29 is a timing chart of an and SOx; Fig. 28 is a timing chart of an SOx graphs showing a cumulative release of the MO_x an SO_x releasing rate; Figs. 27A and 27B are 26B are graphs showing an NOx releasing rate and showing the correction coefficient K; Figs. 26A and the basic fuel injection time; Fig. 25 is a view bustion engine; Fig. 24 is a view showing a map of ing still another embodiment of the internal cominjection time TAU; Fig. 23 is an overall view show-KK; Fig. 22 is a flow chart for calculating the fuel flow charts for calculating the correction coefficient the exhaust gas temperature; Fig. 20 and 21 are temperature; Fig. 19 is a view showing a map of ious types of parameters and the exhaust gas 18D are views showing a relationship between varcontrol at the time of releasing of SOx; Figs. 18A to gas temperature; Fig. 17 is a view showing the rich tween various types of parameters and an exhaust 16A to 16C are views showing a relationship berich control at the time of releasing of NOx; Figs. NOx releasing timing; Fig. 15 is a view showing a the SOx; Fig. 14 is a view showing the SOx and

BEST MODE FOR WORKING THE INVENTION

calculating the fuel injection time TAU.

Figure 1 shows a case where the present in-

Vention is applied to a gasoline engine.

Referring to Fig. 1, 1 denotes an engine body;
2, a piston; 3, a combustion chamber; 4, a spark
plug; 5, an intake valve; 6, an intake port; 7, an
exhaust valve; and 8, an exhaust port; respectively.
The intake port 6 is connected via a corresponding
branch pipe 9 to a surge tank 10, and fuel injectors
11 for injecting the fuel toward inside the intake
port 6 are attached to the respective branch pipes
9, respectively. The surge tank 10 is connected via
an intake duct 12 and an air flow meter 13 to an air
cleaner 14, and 'a throttle valve 15 is arranged in
the intake duct 12. On the other hand, the exhaust
port 8 is connected via the exhaust manifold 16

mixture fed into the combustion chamber 3 is NO_x when the oxygen concentration in the sir-fuel chamber 3 is lean, while releases the absorbed ratio of the air-fuel mixture fed into the combustion absorbent 19 will absorb the NOx when the air-fuel chamber 3, and accordingly, in this case, the NO_x

earths is used. cions metal, alkali metal, alkali earths, or rare same mechanism is realized even if another preand barium Ba are carried on the carrier, but the taking as an example a case where platinum Pt 5A and 5B. Next, this mechanism will be explained be carried out by the mechanism as shown in Figs. absorption and releasing function is considered to absorption and releasing function. However, this uncertainty about the detailed mechanism of this sorption and releasing action, but there are areas of NOx absorbent 19 actually performs the NOx abis arranged in the engine exhaust passage, this When the above-mentioned NOx absorbent 19

absorbed into the NOx absorbent 19. as shown in Fig. 5A. In this way, the NOx is form of the nitric acid ion NO_3- into the absorbent with the barium oxide BaO, while diffused in the while absorbed into the absorbent, and bonded the produced NO₂ is oxidized on the platinum Pt, NO₂ (2NO + O₂ -+ 2NO₂) Subsequently, a part of on the surface of the platinum Pt and becomes inflowing exhaust gas is reacted with O2 or O2- O_2^- or $O^{2-}.$ On the other hand, the NO in the ited on the surface of the platinum Pt in the form of and as shown in Fig. 5A, this oxygen O2 is deposin the inflowing exhaust gas is greatly increased, comes considerably lean, the oxygen concentration Namely, when the inflowing exhaust gas be-

is lean, the NO_x will be released from the NO_x even if the air-fuel ratio of the inflowing exhaust gas leanness of the inflowing exhaust gas is lowered, is lowered, and accordingly when the degree of oxygen concentration in the inflowing exhaust gas ness of the inflowing exhaust gas becomes low, the 19. As shown in Fig. 4, when the degree of leanthe NOx will be released from the NOx absorbent centration in the inflowing exhaust gas is lowered, Namely, this means that, when the oxygen conleased in the form of NO2 from the absorbent. the nitric acid ion NO3 in the absorbent is revanced in a reverse direction ($NO_3^- \rightarrow NO_2$), thus production of NO₂ is lowered, the reaction is adto innome and the barewol si sag tabaka eniwolf to this, when the oxygen concentration in the inand the nitric acid ion NO3- is produced. Contrary saturated, the NO2 is absorbed into the absorbent NOx absorption capability of the absorbent is not on the surface of the platinum Pt, and so far as the flowing exhaust gas is high, the MO₂ is produced So far as the oxygen concentration in the in-

> gions, a lean air-fuel mixture will be burned. Accordingly in most of the engine operating reoperation, and at the time of a full load operation, of a warm-up operation, the time of an acceleration at the constant lean air-fuel ratio except at the time mixture fed into the engine cylinder is maintained. shown in Fig. 3, the air-fuel ratio of the air-fuel made rich. As seen from Fig. 3, in an embodiment the air-fuel mixture fed into the engine cylinder is is made larger than 1.0, that is, the air-fuel ratio of operation is carried out, the correction coefficient K the stoichiometric air-fuel ratio. When a full load tuel mixture fed into the engine cylinder is made for example 1.0, that is, the air-fuel ratio of the airis carried out, the correction coefficient K is made lean. Subsequently, when an acceleration operation mixture fed into the engine cylinder is maintained than 1.0, that is, the air-fuel ratio of the air-fuel cient K is maintained at a constant value smaller the warm up is completed, the correction coeffigine coolant temperature becomes higher. When tion coefficient K is gradually lowered as the en-

combustion chamber 3 becomes leaner. air-fuel ratio of the air-fuel mixture fed into the from the combustion chamber 3 is increased as the of the oxygen O_2 in the exhaust gas discharged chamber 3 becomes richer, while the concentration ratio of the air-fuel mixture fed into the combustion combustion chamber 3 is increased as the air-fuel HC and CO in the exhaust gas discharged from the seen from Fig. 4, the concentration of the unburnt discharged from the combustion chamber 3. As of representative components in the exhaust gas Figure 4 schematically shows the concentration

ratio of the air-fuel mixture fed into the combustion the inflowing exhaust gas coincides with the air-fuel side of the NOx absorbent 19, the air-fuel ratio of not fed into the exhaust passage on the upstream Note that, where the fuel (hydrocarbons) or air is centration in the inflowing exhaust gas is lowered. releasing the absorbed NOx when the oxygen conratio of the inflowing exhaust gas is lean, while releasing of absorbing the NOx when the air-fuel 19 performs the function of NO_x absorption and gas to the NOx absorbent 19, this NOx absorbent bent 19 the air-fuel ratio of the inflowing exhaust passage on the upstream side of the NO_x absorted into the engine intake passage and the exhaust the ratio between the air and fuel (hydrocarbons) is added to this NOx absorbent 19. When calling such as platinum Pt. Note that, desirably lithium Li thanum La and yttrium Y and a precious metal Ba and calcium Ca, and rare earths such as lan-Na, and cesium Cs, alkali earths such as barium from alkali metals such as potassium K, sodium This carrier carries at least one substance selected casing 20 uses for example alumina as the carrier. The NO_x absorbent 19 accommodated in the

be made the stoichiometric air-fuel ratio or rich. that the air-fuel ratio of the inflowing exhaust gas from the NO_x absorbent 19, it is more preferable Accordingly, when the NOx should be released that the NO_x be reduced in the NO_x absorbent 19. absorbent 19 in this way, but it is rather preferred reduce the NO_x on the downstream side of the NO_x NO_x absorbent 19. Of course, it is possible to the reduction agent to the downstream side of the downstream side of the NO_x absorbent 19 or feed brovide a catalyst which can reduce the NOx on the

air-fuel ratio is 18.0 or more. invention be used for removing the NOx when the absorbent 19 which has been used in the present in the end, there is no way except that the NOx that this Cu - zeolite catalyst be used. Accordingly, resistance, and therefore it is not actually preferred more, but this Cu - zeolite catalyst lacks heat reduce the NOx even if the air-fuel ratio is 18.0 or is a Cu - zeolite catalyst as a catalyst which can the MOx under such a lean air-tuel ratio. Also, there the three-way catalyst cannot be used for reducing not sufficiently reduce the NOx, and accordingly duction property under a lean air-fuel ratio, it canor more, even if the three-way catalyst has a re-24 is burned. When the air-fuel ratio becomes 18.0 fuel mixture having an air-fuel ratio of about 20 to and in the embodiment shown in Fig. 1, a lean airthe combustion chamber 3 is almost 18.0 or more, the air-fuel ratio of the air-fuel mixture burned in burned in the combustion chamber 3. In this case, region other than these, a lean air-fuel mixture is eration operation, but in most of the operating stoichiometric air-fuel ratio at the time of the accelfuel ratio of the air-fuel mixture is made the and at the time of full load operation and the airis made rich at the time of the warm-up operation sir-tuel mixture ted into the combustion chamber 3 ing to the present invention, the air-fuel ratio of the · As shown in Fig. 3, in the embodiment accord-

lean air-fuel mixture is burned, and thus the NO_x absorbent 19 is saturated during a period when the tion, the absorption capability of NO_x by the NO_x operation and the time of the acceleration operabsol llut aft to amit aft ts ylno et tnadrozds small, even if the NOx is released from the NOx tion or acceleration operation being carried out is ever, when the frequency of such a full load operaand at the time of the acceleration operation. Howabsorbent 19 at the time of the full load operation this means that the NOx is released from the NOx made the stoichiometric sir-fuel ratio, and therefore operation, the air-tuel ratio of the air-tuel mixture is made rich, while at the time of an acceleration mixture fed into the combustion chamber 3 is full load operation, the air-fuel ratio of the air-fuel invention, as mentioned above, at the time of the In the embodiment according to the present

spsorbent 19.

a snort time. rich, NOx is released from the NOx absorbent 19 in air-fuel ratio of the inflowing exhaust gas is made ausorbent. Accordingly, this means that, when the Pt, the NO₂ is successively released from the NO2 no longer exists on the surface of the platinum duced as shown in Fig. 5B. In this way, when the is reacted with the unburnt HC and CO and re-NO₂ is released from the absorbent, and this NO₂ haust gas is extremely lowered, and therefore the rich, the oxygen concentration in the inflowing exfuel ratio of the inflowing exhaust gas becomes the platinum Pt and oxidized. Also, when the airsud CO are reacted with the oxygen $\ensuremath{\text{O}_{\text{S}}}\xspace^-$ or $\ensuremath{\text{O}_{\text{S}}}\xspace^-$ on Charged from the engine, and these unburnt HC large amount of unburnt HC and CO are disexhaust gas becomes rich, as shown in Fig. 4, a is made rich and the air-fuel ratio of the inflowing sir-fuel mixture fed into the combustion chamber 3 On the other hand, when the air-fuel ratio of the

the NO_x absorbent 19. time is required for releasing all NOx absorbed in the NOx absorbent 19, and therefore a slightly long ratio, the NOx can be only gradually released from exhaust gas is made the stoichiometric air-fuel However, where the air-fuel ratio of the inflowing released from the NOx absorbent 19 is reduced. is made the stoichiometric air-fuel ratio, the NO_{x} even if the air-fuel ratio of the inflowing exhaust gas has a function of a reduction catalyst, and therefore into the atmosphere. Also, the NOx absorbent 19 that it is possible to prevent the discharge of MOx released NOx is reduced, and therefore this means 19 is released in a short time, and in addition, this made rich, the NOx absorbed in the NOx absorbent the air-fuel ratio of the inflowing exhaust gas is by these unburnt HC and CO. Accordingly, when the NO_x discharged from the engine are reduced sumed, the NOx released from the absorbent and if the O_2^- or O^{2-} on the platinum Pt are conquently if the unburnt HC and CO still remain even or ${\rm O}^{2-}$ on the platinum Pt and oxidized, and subse-HC and CO are immediately reacted with the O2exhaust gas is made rich, first of all, the unburnt Namely, when the air-fuel ratio of the inflowing

19, and accordingly in this case, it is necessary to 19, the NOx is not reduced in the NOx absorbent though the NOx is released from the NOx absorbent neve nsel si seg taushxe gniwoltni edt to oitst flowing exhaust gas is lowered. Note, if the air-fuel sufficient if the oxygen concentration in the inrelease the NO_x from the NO_x absorbent 19, it is from the NOx absorbent 19. Accordingly, so as to inflowing exhaust gas is lean, the NOx is released mentioned before, even if the air-fuel ratio of the ratio of the inflowing exhaust gas is made low as Muen the degree of leanness of the sir-fuel

on the carrier made of alumina is the most preis clarified that the absorbent carrying the lithium Li ium Li on a carrier made of alumina. In this case, it nickel Ni, sodium Na, tin Sn, titanium Ti, and lithsuch as copper Cu, iron Fe, manganese Mn, and least one member selected from a transition metal use can be made of an absorbent which carries at produced. As the SO_x absorbent 18 enabling this, an unstable state even if the sulfate BaSO4 is to make the sulfate BaSO4 exist in the absorbent in bent in the form of the sulfuric acid ion SO42-, or sary to make the absorbed SOx exist in the absor-SO_x absorbent 18 is made rich, it becomes necesthe air-fuel ratio of the exhaust gas flowing into the release the SO_x from the SO_x absorbent 18 when from the NO_x absorbent 19. Accordingly, so as to 19 is made rich, the SOx no longer will be released of the exhaust gas flowing into the NOx absorbent

the downstream side of the SO_x absorbent 18. absorbed into the NO_x absorbent 19 provided on absorbent 18, and accordingly only the NOx is becomes lean, the SOx is absorbed into the SOx 81 Inadvocas xOS ant of of of of of others of the SOx absorbent 18 mentioned above, when the air-fuel ratio of the carried on the carrier of the SO_x absorbent 18. As sorption of the SO2, preferably the platinum Pt is ion SO₄ 2-. Accordingly, so as to promote the abinto the absorbent in the form of the sulfuric acid SO₃2-, and thus the SO₂ becomes easily absorbed easily adhered onto the platinum Pt in the form of carrier of the SOx absorbent 18, SOx becomes In this case, when the platinum Pt is caught on the acid ion SO.2- and then diffused in the absorbent. sorbed into the absorbent in the form of the sulfuric oxidized on the surface of the absorbent and ab-18 is lean, the SO_x contained in the exhaust gas is of the exhaust gas flowing into the SOx absorbent In this SO_x absorbent 18, when the air-fuel ratio

On the other hand, as mentioned before, the SO_x absorbent 18 has been SO_x absorbent 18 has been diffused in the absorbent in the form of the sulfuric acid ion SO_4^{2-} , or has become the sulfate BaSO₄ in an unstable state. Accordingly, when the sir-fuel ratio of the exhaust gas flowing into the SO_x absorbent 18 becomes rich, the SO_x absorbed in the SO_x absorbent 18 will be released from the SO_x absorbent 18. At this time, the NO_x is simultaneously released from the NO_x absorbent 19.

As mentioned before, when the NO_2 on the surface of the platinum Pt no longer exists, in the NO_x absorbent 19, the reaction is immediately advanced in the direction of $(NO_3^- \to NO_2)$, and the NO_x is immediately released from the absorbent. When the sir-fuel ratio of the exhaust gas flowing into the NO_x absorbent 19 is made rich, the NO_z on the surface of platinum Pt is immediately reduced by the unburnt HC and CO, and therefore

can no longer be absorbed by the MO_x absorbent 19. Accordingly, when the lean air-fuel mixture is being continuousl burned, it is necessary to periodically make the air-fuel ratio of the inflowing exhaust gas rich or periodically make the sir-fuel sario of the inflowing exhaust gas the stoichiometric ratio of the inflowing exhaust gas the MO_x from the NO_x absorbent 19.

 SO_x is contained in the exhaust gas, and not only MO_x , but also SO_x are absorbed into the MO_x absorbent 19. It can be considered that the mechanism of the absorption of SO_x into the MO_x absorbent 19 is the same as the absorption mechanism of the MO_x .

sulfate BaSO4. the sulfuric acid ion SO_4^{2-} to produce a stable BaO, while diffused in the absorbent in the form of the absorbent, and bonded with the barium oxide oxidized on the platinum Pt, while absorbed into sequently, a part of the produced SO3 is further surface of the platinum Pt and becomes SO3. Subexpanst gas reacts with the O_2^- or O^{z-} on the form of O2 or O2", and the SOx in the inflowing deposited on the surface of the platinum Pt in the inflowing exhaust gas is lean, the oxygen O2 is as mentioned before, when the air-fuel ratio of the explanation of the absorption mechanism of NOx, are carried on the carrier in the same way as in the example a case where platinum Pt and barium Ba Namely, when explaining this by taking as an

However, this sulfate BaSO₄ is stable and difficult to decompose, and even if the air-fuel ratio of the inflowing exhaust gas is made rich, the sulfate BaSO₄ remains as it is without decomposition. Accordingly, as the time is elapsed, the sulfate BaSO₄ is increased in the NO_x absorbent 19, and thus as time elapses, the amount of NO_x that can be absorbed by the NO_x absorbent 19 will be lowered.

is usage tich. 81 Inedioads xO2 ant of of of the SOx absorbent 18 but also the absorbed SO_x when the air-fuel ratio of 18 is lean, but releases not only the absorbed NOx, of the exhaust gas flowing into the SOx absorbent also NOx together with SOx when the air-fuel ratio Nox absorbent 19. This \$O_x absorbent 18 absorbs catalyst, is arranged on the upstream side of the the same time, has a function of the three-way of the inflowing exhaust gas becomes rich and, at releases the absorbed SO_x when the air-fuel ratio ratio of the inflowing exhaust gas is lean, while pent 18 which absorbs the SOx when the air-fuel flowing into the NO_x absorbent 19, an SO_x absorpresent invention, so as to prevent the SOx from Therefore, in the embodiment according to the

As mentioned above, in the $NO_{\rm x}$ absorbent 19, when the $SO_{\rm x}$ is absorbed, a stable sulfate BaSO4 is formed, and as a result, even if the sir-fuel ratio

19 is estimated from the cumulative value of the the amount of MOx absorbed in the MOx absorbent embodiment shown in Fig. 1, it is simplified and intake air amount and the engine load, but in the from the cumulative value of the product of the specified in the NOx absorbent 19 can be estimated engine load. Accordingly, the amount of the NOx rectly in proportion to the intake air amount and specified into the NOx absorbent 19 becomes corengine load, and therefore the amount of NO_x NOx in the exhaust gas is in proportion to the to the intake air amount, and the concentration of this case, the exhaust gas amount is in proportion and the NOx concentration in the exhaust gas. In amount of the exhaust gas discharged from engine the NO_x absorbent 19 is in proportion to the of the same. The amount of the NO_x absorbed into 20 bercent based on the total absorption capability Nox absorbent 19 absorbs the NOx in an amount of sorbed into the NO_x absorbent 19, for example, the when the predetermined amount of NO_x is ab- NO_x from the NO_x absorbent 19 are carried out

Figure 7 shows an interruption routine executthe NOx absorbent 19 referring to Fig. 7 and Fig. 8. bodiment of the absorption and releasing control of Next, an explanation will be made of one emengine rotational speed.

ed at every predetermined time interval.

later, the air-fuel ratio of the air-fuel mixture to be the NOx releasing flag is set, as will be mentioned 103, at which the NOx releasing flag is set. When absorbent 19, the processing routine goes to step NO_x absorbent 19 has been absorbed in the NO_x pased on the total NOx absorption capability of the timated that the NOx in an amount of 50 percent while when IME > SNE, that is, when it is es-∑NE ≤ SNE, the processing cycle is completed, been absorbed in the NO_x absorbent 19. When sorption capability of the NOx absorbent 19 has example 20 bercent based on the total NOx abto for an amount of tor to the NOx in an amount of for dicates the cumulative rotational speed from which constant value SNE. This constant value SNE inmulative rotational speed ZNE is larger than the step 102, it is determined whether or not the cuthe engine rotational speed NE. Subsequently, at ingly, this ZNE indicates the cumulative value of engine rotational speed NE is made ZNE. Accordwhich the result of addition of DNE to the current burned, the processing routine goes to step 101, at 1.0, that is, when a lean air-fuel mixture is being lean air-fuel mixture is being burned. When K < TP is smaller than 1.0, that is, whether or not a cient K with respect to the basic fuel injection time determined whether or not the correction coeffi-Referring to Fig. 7, first of all, at step 100, it is

ted into the engine cylinder is made rich.

erably high. releasing speed of the NOx absorbent 19 is consida short time. Namely, this means that the NOx the NOx will be released from the NOx absorbent in diately disappears, and thus, as shown in Fig. 6, the NO2 on the surface of the platinum Pt imme-

speed of the NO_x. considerably slow in comparison with the releasing this means that the releasing speed of the SOx is SO_x is completed in comparison with NO_x . Namely, a long time is required until the releasing of the exhaust gas to the SOx absorbent 18 is made rich, Fig. 6, even if the air-fuel ratio of the inflowing speed is considerably slow, and thus, as shown in released from the absorbent. This decomposition SO_x in the SO_x absorbent 18 is decomposed and flowing into the SOx absorbent 18 is made rich, the Namely, when the air-fuel ratio of the exhaust gas flowing into the SO_x absorbent 18 is made rich. caused unless the air-fuel ratio of the exhaust gas absorbent 19. The decomposition of this SOx is not more stable than the NO_x absorbed in the NO_x absorbent 18 is difficult to decompose since it is Contrary to this, the SOx absorbed in the SOx

das is made rich. bent 19, the air-fuel ratio of the inflowing exhaust the NOx should be released from the NOx absorshould be released from the SO_x absorbent 18 and cording to the present invention, when the SO_x spsorbent 18. Accordingly, in the embodiment acmade rich, the SO_x is not released from the SO_x the air-fuel ratio of the inflowing exhaust gas is not the stoichiometric air-fuel ratio or rich. However, if air-fuel ratio of the inflowing exhaust gas is made released from the NOx absorbent 19, preferably the As mentioned before, when the NOx should be

pecowes swall. et finedroads xON ent of or salvante sur salvante et finedroads xON entre finedroads xON entr speotpeut 19 is completed. Accordingly, the 19 after the NOx releasing action from the NOx the SOx absorbent 18 flows into the NOx absorbent accordingly the most part of the SO2 released from releasing speed of the SOx as shown in Fig. 6, and speed of the NOx is considerably slower than the SO4-. However, as mentioned before, the releasing to most and in 61 thedroads xON and offin bedroa SO₃ + NO), and thus the produced SO₃ is abreacted in the NO_x absorbent 19 (SO₂ + NO₂ → the NOx absorbent 19, the SO2, and the NO2 are absorbent 19 when the MO2 is being released from from the SOx absorbent 18 flows into the MOx Nox absorbent 19. However, if the SOx released absorbent 18, and the NOx is released from the gas is made rich, the SOx is released from the SOx When the air-fuel ratio of the inflowing exhaust

SOx absorbent 18 and the releasing action of the in Fig. 1, the releasing action of the SO_{κ} from the On the other hand, in the embodiment shown

where K \ge 1.0 as the engine coolant temperature becomes higher. Also, at the time of the acceleration operation, the correction coefficient K is made a value larger than correction coefficient K is made a value larger than 1.0. Subsequently, at step 203, the correction coefficient K is made Kt, and then at step 204, the efficient K is made Kt, and then at step 204, the tuel injection time TAU (= TP • Kt) is calculated. At this time, the sir-fuel ratio of the sir-fuel mixture fed into the engine cylinder is made the stoichiometric sir-fuel ratio or rich.

in the MOx absorbent 19 will be released. released and, at the same time, the NO_x absorbed SO_x absorbed in the SO_x absorbent 18 will be mixture is fed into the engine cylinder, whereby the 13.5. Accordingly, at this time, the rich air-fuel ted into the engine cylinder becomes about 12.0 to with which the air-fuel ratio of the air-fuel mixture 204. This value KK is a value of about 1.1 to 1.2 Kt, and then the processing routine goes to step 208, at which the predetermined value KK is made ing flag is set, the processing routine goes to step when it is decided at step 205 that the NOx releasted into the engine cylinder. On the other hand, cordingly, at this time, the lean air-fuel mixture is Kt, the processing routine goes to step 204. Acstep 207, after the correction coefficient K is made coefficient K is made for example 0.6, and then at routine goes to step 206, at which the correction releasing flag has not been set, the processing NOx releasing flag has been set. When the NOx 205, at which it is determined whether or not the carried out, the processing routine goes to step combustion of a lean air-fuel mixture should be step 201 that it is the operation state where the On the other hand, when it is determined at

Figure 9 shows another embodiment. In this embodiment, the same constituent elements as those shown in Fig. 1 are indicated by the same symbols.

As shown in Fig. 9, in this embôdiment, an exhaust manifold 16 is connected to the inlet portion of a casing 41 containing an SO_x absorbent 40, and the outlet portion of the casing 40 is connected via the exhaust pipe 42 to the inlet portion of a casing 44 containing an NO_x absorbent 43. Also in this embodiment, when the lean air-fuel mixture is being burned in the combustion chamber 3, the SO_x is absorbent 40 and, at the same time, the NO_x is absorbent 40 and, at absorbent 43. On the other hand, when the sir-fuel ratio of the sir-fuel mixture fed into the combustion chamber 3 is made rich, the SO_x is released from the SO_x absorbent 40, and the NO_x is released from the SO_x absorbent 40, and the NO_x is released from the SO_x absorbent 40, and the NO_x is released from from the NO_x absorbent 43.

Figure 10 shows a case where the present invention is applied to a diesel engine. Note that, in Fig. 10, constituent elements the same as those

tional speed ZNE and the count value C are made Subsequently, at step 107, the cumulative rotathe engine cylinder is made rich for 5 seconds. thus the air-fuel ratio of the air-fuel mixture fed into engine cylinder is switched from rich to lean, and the air-fuel ratio of the air-fuel mixture fed into the releasing flag is reset, as will be mentioned later, the NOx releasing flag is reset. When the NOx the processing routine goes to step 106, at which completed, and when C becomes smaller than Co, elapsed. When C 2 Co, the processing routine is is whether or not for example 5 seconds have C becomes larger than the constant value Co, that 105, it is determined whether or not the count value incremented exactly by one. Subsequently, at step Subsequently, at step 104, the count value C is

On the other hand, at step 100, when it is decided that K \geq 1.0, that is, when the sir-fuel ratio of the sir-fuel mixture being fed into the engine cylinder is the stoichiometric sir-fuel ratio or rich, the processing routine goes to step 108, at which it determined whether or not the state of K \geq 1.0 is continued for the predetermined time, for example, 10 seconds. When the state of K \geq 1.0 is not continued for the predetermined time, the processing cycle is completed, and when the state of K \geq 1.0 is not ing cycle is completed, and when the state of K \geq 1.0 is not the predetermined time, the processing routine goes to step 109, at which the cumulative rotational speed \geq 1ME is made sero.

Namely, when the time during which the sirtuel ratio of the sir-fuel mixture fed into the engine cylinder is made the stoichiometric sir-fuel ratio or rich continues for about 10 seconds, it is considered that the most part of the SO_x absorbed in the SO_x absorbent 18 was released and, at the same time, the most part of the NO_x absorbed in the NO_x absorbent 19 was released, and accordingly, in this absorbent 19 was released.

Figure 8 shows a calculation routine of the basic fuel injection time TAU, which routine is repeatedly executed

Heterring to Fig. 8, first, at step 200, the basic fuel injection time TP is calculated from the map shown in Fig. 2. Subsequently, at step 201, it is determined whether or not the operation state is should be carried out. When it is not the operation state where the combustion of a lean air-fuel mixture should be carried out, that is, at the time of the operation of the time of the scceleration operation or the time of the full load operation, the processing routine goes to step 202, at which the correction coefficient K is calculated, At the time of the engine warm-up operation, this correction coefficient K is a function of the engine coolant teme of the engine warm-up operation, this correction coefficient K is a function of the engine coolant temportation.

bon at this time is determined so that the air-fuel ratio of the inflowing exhaust gas flowing into the SO_x absorbent 18 and the NO_x absorbent 18 and sccordingly, at this time, the SO_x will be released from the SO_x absorbent 18, and the NO_x will be released from the NO_x absorbent

Figure 11 shows a routine for executing this NO_x releasing processing, which routine is executed by interruption at every predetermined time interval.

made zero. at step 304, the cumulative rotational speed ENE is pie, for about 5 seconds to 20 seconds, and then, valve 60 is opened for a constant time, for examsequently, at step 303, the reduction agent feeding example, for about 5 seconds to 20 seconds. Subfeeding pump 61 is driven for a constant time, for cessing routine goes to step 302, at which the been absorbed in the NOx absorbent 19, the proabsorption capability of the NOx absorbent 19 has an amount of 50 percent based on the total MO_{x} SNE, that is, when it is estimated that the NOx in processing cycle is completed, while when ENE > the NO_x absorbent 19. When ∑NE ≤ SNE, the ity of the NOx absorbent 19 has been absorbed in percent based on the total NOx absorption capabilthat the NOx in an amount of for example 50 mulative rotational speed from which it is estimated SNE. This constant value SNE indicates the cutional speed ZNE is larger than the constant value is determined whether or not the cumulative rotarotational speed NE. Subsequently, at step 301, it ENE indicates the cumulative value of the engine rotational speed NE is made ENE. Accordingly, this result of addition of ENE to the current engine Referring to Fig. 11, first of all, at step 300, the

Figure 12 shows a further embodiment. Note that, in Fig. 12, constituent elements the same as those shown in Fig. 1 are indicated by the same

Referring to Fig. 12, in this embodiment, a temperature sensor 22 is arranged in the exhaust pipe 17 on the upstream side of the casing 20. This temperature sensor 22 generates an output voltage in proportion to the exhaust gas temperature flowing in the exhaust pipe 17, and this output voltage is input to the input port 35 via the AD voltage is input to the input port 35 via the AD converter 37. Further, in this embodiment, a bidirectional bus 31 is connected to a backup RAM 33a always connected to the power source.

This embodiment prevents the SO_x released from the SO_x absorbent 18 from being absorbed into the MO_x absorbent 19 as much as possible. Note that, in this embodiment, the releasing control of the SO_x and MO_x is carried out considering also the temperature of the SO_x absorbent 18, Accordingly, first of all, an explanation will be made of a ingly, first of all, an explanation will be made of a

shown in Fig. 1 are indicated by the same symbols.

the NOx absorbent 19 is made rich. inflowing exhaust gas to the SOx absorbent 18 and spacepent 18, whereby the air-fuel ratio of the exhaust passage on the upstream side of the SO_x and the hydrogen carbide is fed into the engine mixture in the combustion chamber 3 is made lean in Fig. 10, the average air-fuel ratio of the air-fuel made rich. In this case, in the embodiment shown the SO_x absorbent 18 and the NO_x absorbent 19 is 19, the air-fuel ratio of the exhaust gas flowing into 140x should be released from the NOx absorbent the SOx absorbent 18 and, at the same time, the other hand, when the SO_x should be released from time is absorbed into the NOx absorbent 19. On the SOx absorbent 18, and the NOx discharged at this SOx discharged at this time is absorbed into the combustion chamber 3 is lean. Accordingly, the sverage air-fuel ratio of the air-fuel mixture in the an air excess rate is 1.0 or more, that is, the states, combustion is performed in a state where In the diesel engine, usually in all operation

nilea. liquid state, for example, butane or propane is lamp oil, or a hydrocarbon which can be stored in a gasoline, isooctane, hexane, heptane, light oil or a duction agent tank 62, a hydrocarbon such as and the feeding pump 61, respectively. In the re-Circuits 38 to the reduction agent feeding valve 60 electronic control unit 30 is connected via drive reduction agent tank 62. The output port 36 of the valve 60, is connected via a feeding pump 61 to a exhaust pipe 17, which reduction agent feeding reduction agent feeding valve 60 is arranged in an the input port 35. Also, in this embodiment, a load sensor 51 is input via the AD converter 52 to pedal 50 is provided, and the output voltage of this tion to an amount of depression of an accelerator seusor 51 generating an output voltage in propor-Referring to Fig. 10, in this embodiment, a load

seconds. The amount of feeding of the hydrocarconstant time, for example, about 5 seconds to 20 agent feeding valve 60 to the exhaust pipe 17 for a reduction agent tank 62 is fed from the reduction 60 is opened, whereby the hydrocarbon filled in the at the same time, the reduction agent feeding valve absorbent 19, the feeding pump 61 is driven and, time the NO_x should be released from the NO_x leased from the SO_x absorbent 18 and, at the same NOx absorbent 19. When the SOx should be redischarged from the engine is absorbed into the absorbent 18 and, at the same time, the NO_x charged from the engine is absorbed into the SO_x sir-fuel ratio is lean. At this time, the SOx disexcess of air, that is, in a state where the average compression chamber 3 is usually burned under an In this embodiment, the air-fuel mixture in the

symbols.

fuel ratio of air-fuel mixture is made rich for about several seconds when the NO_x is to be released, the air-fuel ratio of air-fuel mixture is made rich for eased. In this way, the air-fuel ratio of air-fuel mixture is made rich over a long time when the SO_x is released, but as mentioned above, a period for which the air-fuel ratio of air-fuel mixture is made rich for the release of the SO_x is long, and therefore a great increase of the SO_x is long, and

Figure 15 shows a rich control of the air-fuel mixture when releasing the ${\rm MO}_{\rm x}$ (P of Fig. 14). Note that, Kt indicates the correction coefficient with respect to the basic fuel injection time TP.

amount will not be caused by this.

As shown in Fig. 15, when the MO_x should be released from the MO_x absorbent 19, the sir-fuel ratio of the sir-fuel mixture sir-fuel ratio of the sir-fuel mixture sir-fuel ratio of the sirbuel mixture fed into the combustion chember 3 is made rich by increasing the correction coefficient Kt is gradually reduced, and then the correction coefficient Kt is gradually reduced, and then the correction coefficient Kt is maintained at 1.0, that is, the sir-fuel ratio of the sir-fuel mixture fed into the combustion chamber 3 is maintained at the stoichiometric sir-fuel ratio. Subsequently, when the stoichiometric sir-fuel ratio. Subsequently, when started, the correction coefficient Kt is made small-started, the correction coefficient Kt is made small-

air-fuel mixture is started again.

in Fig. 16B are stored in advance in the ROM 32. time C1 and the exhaust gas temperature T shown shown in Fig. 16A and the relationship between the coefficient KK and the exhaust gas temperature T Note that, a relationship between the correction the exhaust gas temperature T becomes higher. shown in Fig. 16B, the time Cr is made shorter as exhaust gas temperature T becomes higher, and as correction coefficient KK is made larger as the Accordingly, as shown in Fig. 16A, the value of the leased from the NO_x absorbent 19 is increased. 19 becomes higher, the amount of the NOx rehigher and the temperature of the NO_x absorbent case, as the exhaust gas temperature becomes and reducing the whole NOx at this time. In this the O2- or O2- on the surface of the platinum Pt HC and CO in an amount necessary for consuming C1 are determined so as to generate the unburnt value of the correction coefficient KK and the time and NO_x absorbent 19 is abruptly released. The (Kt = KK), the most part of the NO_x absorbed in ted into the combustion chamber 3 becomes rich When the air-fuel ratio of the air-fuel mixture

On the other hand, as mentioned before, when the sir-fuel ratio of the sir-fuel mixture fed into the combustion chamber 3 becomes rich (Kt=KK), the most part of the NO_x absorbed in the NO_x

relationship between the temperature of the SO_x. absorbent 18 and the releasing function of the SO_x. Namely, the decomposition function of the SO_x are decomposition function of the SO_x.

T of the SO_x absorbent 18 becomes lower. bent 18 must been made richer as the temperature ratio of the exhaust gas flowing into the SOx absor-Fig. 13 that, so as to release the SOx, the air-fuel perature T of the SO_x absorbent 18. It is seen from absorbent 18 can release the SOx and the tem-of the inflowing exhaust gas with which the SO_x AlA oits leut-ris ent neewted qinsnoitsler s sworts released from the SO_x absorbent 18 Figure 13 made rich, and thus this means that the SOx is not sir-fuel mixture flowing into the SOx absorbent 18 is to be decomposed unless the air-fuel ratio of the pent 18 becomes lower, the SOx becomes harder Accordingly, as the temperature of the SO_x absorperature of the SO_x absorbent 18 becomes lower. decomposition becomes more difficult as the temtemperature of the SOx absorbent 18, and the absorbed in the SOx absorbent 18 depends on the

made rich with a proportion of one time per several example, the air-fuel ratio of air-fuel mixture is trom the SOx absorbent 18 is considerably long, for fuel mixture is made rich so as to release the SO_x ingly, the period for which the air-fuel ratio of air-SO_x absorbent 18 is saturated by the SO_x. Accordtherefore a considerably long time is taken until the smaller in comparison with the amount of NOx, and SO_x contained in the exhaust gas is considerably several minutes. On the other hand, the amount of is made rich with a proportion of one time per erably short, and the air-fuel ratio of air-fuel mixture ratio of the air-fuel mixture is made rich is consid-NO_x absorbent 19, the period for which the air-fuel from Fig. 14, so as to release the NO_x from the is released from the SOx absorbent 18. As seen bent 19, and Q indicates a timing at which the SO_x at which the NOx is released from the NOx absorthis way. Note that, in Fig. 14, P indicates a timing air-fuel ratio of the air-fuel mixture is made rich in made rich, and Fig. 14 shows a timing at which the into the combustion chamber 3 is periodically SO_x should be released, the air-fuel mixture fed Also in this embodiment, when the NOx and

As shown in Fig. 6, when the sir-fuel ratio of the sir-fuel mixture fed into the combustion chamber 3 is made rich, the NO_x is released from the NO_x absorbent 19 in a short time, but a considerably long time is required until the SO_x is released from the SO_x absorbent 18. Accordingly, in this embodiment, a time for which the sir-fuel ratio of sir-fuel mixture is continuously made rich so as to release the SO_x is made considerably longer than the time for which the sir-fuel ratio of sir-fuel mixture is continuously made rich so as to release the ture is continuously made rich so as to release the ture is continuously made rich so as to release the fure is continuously made rich so as to release the sir-fuel mixture is continuously made rich so as to release the fure is continuously made rich so as to release the fure is continuously made rich so as to release the fure is continuously made rich so as to release the later fine for which in contrast to a fact that the sir-

uonus:

3 minutes to 10 minutes. the NOx shown in Fig. 15 and for example is about parison with the time C₁ at the time of releasing of the SOx is released is considerably longer in comture is started again. Note that, the time C2 when again, and the combustion of the lean air-fuel mixcorrection coefficient Kt is made smaller than 1.0 C2 has elapsed when the rich control is started, the richness (Kt = KK). Subsequently, when the time richness (Kt = Ko) smaller than this first degree of and thereafter maintained at a second degree of rich up to the first degree of richness (Kt = KK),

bisined next. tich (Kt = KK). The reason for this will be exall, the sir-fuel ratio of air-fuel mixture is made very SOx should be released irrespective of this, first of leased well from the SOx absorbent 18. When the cient Kt is maintained at Ko, the SOx will be re-Ko in Fig. 17. Accordingly, if the correction coeffiand this lowest degree of richness is indicated by richness with which the NOx can be released well, fuel mixture is maintained at the lowest degree of SOx should be released, the sir-fuel ratio of the sirtuel consumption amount. Accordingly, when the mixture very rich leads to only an increase of the Namely, making the air-fuel ratio of the air-fuel ing of the SOx cannot be completed in a short time. tuel mixture is continuously made rich, the releasand accordingly even if the air-fuel ratio of the airfrom the SOx absorbent 18 is considerably slow, As mentioned before, the SOx releasing speed

mixture is made very rich (Kt = KK). released, first of all the air-fuel ratio of the air-fuel pose, as shown in Fig. 17, when the SO_x should be released from the SOx absorbent 18. For this purthe NO_x absorbent 19 when the SO_x is being necessary to prevent the NO2 from releasing from from absorption into the NOx absorbent 19, it is exist, and accordingly so as to prevent the SO₂ reaction is not caused so far as the NO₂ does not the NOx absorbent 19 in the form of SO4-. Such a and thus the produced SO3 will be absorbed into react with each other (SO₂ + NO₂ → SO₃ + NO), this way, as mentioned before, the NO2 and SO2 gradually released from the NOx absorbent 19 in flowing into the NO_x absorbent 19 when the NO_x is the SO_x released from the SO_x absorbent 18 is leased also from the NOx absorbent 19. However, if is small, and therefore the NO_x is gradually rethe NO_x absorbent 19, but the degree of richness this time, the NOx is simultaneously released from gradually released from the SOx absorbent 18. At Ko when the SO_x should be released, the SO_x is If the correction coefficient Kt is maintained at

at one time, and thereafter almost no NO2 is reof the NO2 is released from the NOx absorbent 19 mixture is made very rich (Kt = KK), the most part Namely, when the air-fuel ratio of the air-fuel

> sequentially reduced. gradually released from the NOx absorbent 18 is stoichiometric air-fuel ratio (Kt = 1.0), and the NO_x quently the air-fuel ratio is maintained at the richness is made gradually smaller, and subsefuel ratio is made rich (Kt = KK), the degree of this embodiment, as shown in Fig. 15, after the airwill be released into the atmosphere. Therefore, in continuously made rich, the unburnt HC and CO little by little. Accordingly, when the air-fuel ratio is NO_x is released from the NO_x absorbent 19 only even if the air-fuel ratio has been made rich, the absorbent 19 is abruptly released, and thereafter

the ROM 32. ture T shown in Fig. 16C is stored in advance in between the time C2 and the exhaust gas temperature T becomes higher. Note that, a relationship again is made shorter as the exhaust gas temperafuel ratio is made rich to when it is returned to lean shown in Fig. 16C; a time C2 of from when the airthe air-fuel ratio is made rich, and accordingly, as from the NOx absorbent 19 becomes larger when T becomes higher, the amount of the NOx released mentioned before, as the exhaust gas temperature sorbent 19 ends releasing NOx becomes short. As sinaller, and accordingly a time until the NOx abreleased from the NO_x absorbent 19 becomes fuel ratio is made rich, the amount of the NO_x from the NO_x absorbent 19 is larger when the air-Note that, as the amount of the NOx released

lessing action from the NOx absorbent 19 is carried absorbent 18, and substantially only the NOx retherefore almost no SO_{κ} is released from the SO_{κ} tuel ratio of air-fuel mixture is rich is short, and low. Note that, in this case, a time for which the airof Fig. 15 when the exhaust gas temperature I is changed with a pattern indicated by a broken line pattern indicated by a solid line of Fig. 15, and the correction coefficient Kt is changed with a and when the exhaust gas temperature T is high, secoldance with the exhaust gas temperature 1, In this way, KK, C1, and C2 are controlled in

mixture when the SO_x is released (Q in Fig. 14). Figure 17 shows the rich control of the air-fuel

all, the air-fuel ratio of air-fuel mixture is made very Namely, when the SOx should be released, first of pnation chamber 3 is continuously maintained rich. tuel ratio of the air-fuel mixture fed into the comcient Kt is maintained at Ko (> 1.0), that is the airgradually reduced, and then the correction coeffi-C1. Subsequently, the correction coefficient Kt is then maintained at this rich state only for the time the correction coefficient Kt up to KK (>1.0), and combustion chamber 3 is made rich by increasing air-fuel ratio of the air-fuel mixture fed into the should be released from the SOx absorbent 18, the As shown in Fig. 17, even when the SO_x

the time C_2 and the exhaust gas temperature T shown in Fig. 18D is stored in advance in the ROM or

T is calculated from this map. * shown in Fig. 19 and the exhaust yas temperature vance in the ROM 32 in the form of a map as experiments and this relationship is stored in adengine rotational speed N is found in advance from temperature T, the intake air amount Q, and the cient if the relationship among the exhaust gas engine rotational speed N. In this case, it is suffithe same from the intake air amount Q and the temperature T, but it is also possible to estimate it is also possible to directly detect the exhaust gas detected by the temperature sensor 22. In this way, this embodiment, this exhaust gas temperature T is functions of the exhaust gas temperature T, and in 18D, the various values KK, C1, Ko, and C2 are As shown in Figs. 16A to 16C and Figs. 18A to

Next, the absorption and releasing control of the $NO_{\rm x}$ and $SO_{\rm x}$ will be explained referring to Fig.

20 to Fig. 22 show a calculation routine of the correction coefficient KK at the time of tine of the control, which routine is executed by interruptich control, which routine is executed by interruption.

tion at every predetermined time interval.

Referring to Fig. 20 and Fig. 21, first of all, it is determined at step 400 whether or not the correction coefficient K is smaller than 1.0, that is, whether or not the lean sir-fuel mixture is being burned, the processing routine mixture is being burned, the processing routine goes to step 401, at which the amount Wn of NO_x gbsorbed in the absorbent 19 is calculated. Namely, the amount of NO_x discharged from the combustion chamber 3 is increased as the intake sir amount Q becomes larger, and increased as the engine load Q/N becomes higher, and therefore the engine load Q/N becomes higher, and therefore the engine load Q/N becomes bigher, and sheetone the bent 19 will be represented by the sum of Wn and bent 19 will be represented by the sum of Wn and

releasing flag has not been set, the processing should be released has been set. When the NOx not the NOx releasing flag indicating that the NOx to step 404, at which it is determined whether or flag has not been set, the processing routine goes released has been set. When the SOx releasing releasing flag indicating that the SOx should be step 403, it is determined whether or not the SOx is stored in the backup RAM 33a. Subsequently, at and K2 • Q (k2 is a constant). This SOx amount Ws spaceful 18 will be represented by the sum of Wn the amount VN of the SO_x absorbed in the SO_x intake air amount Q becomes larger, and therefore from the combustion chamber 3 is increased as the calculated. Namely, the amount of SO_x discharged the SO_x absorbed in the SO_x absorbent 18 is Subsequently, at step 402, the amount Ws of

leased form the NO_x absorbent 19. Accordingly, thereafter the SO_2 released from the SO_x absorbent 18 will not react with the NO_2 when the correction coefficient Kt is maintained at Ko, and thus a risk of absorption of the SO_2 into the NO_x absorbent 19 is eliminated.

C1 and the exhaust gas temperature T shown in in Fig. 18A and the relationship between the time cient KK and the exhaust gas temperature T shown fust, a relationship between the correction coeffiexhaust gas temperature T becomes higher. Note Fig. 18B, the time C₁ is made shorter as the temperature T becomes higher, and as shown in coefficient KK is made larger as the exhaust gas shown in Fig. 18A, the value of the correction Nox absorbent 19 is increased. Accordingly, as higher, the amount of the NO_x released from the ingly the temperature of the NOx absorbent 19 is the exhaust gas temperature is higher, and accordbent 19 is abruptly released, and at this time, as most part of the NOx absorbed in the NOx absorthe sir-fuel mixture becomes rich (Kt = KK), the As mentioned before, when the air-fuel ratio of

Fig. 18B are stored in advance in the ROM 32.

stored in advance in the ROM 32. haust gas temperature T, which relationship is relationship between this value of Ko and the ex-Ko is made relatively large. Figure 18C shows a indicated by a broken line in Fig. 17, the value of and when the exhaust gas temperature T is low, as in Fig. 17, the value of Ko is made relatively small, temperature T is high, as indicated by a solid line is made smaller. Namely, when the exhaust gas higher, the air-fuel ratio A/F of the air-fuel mixture ment, as the exhaust gas temperature T becomes mixture is lowered. Accordingly, in this embodireleased even if the air-fuel ratio A/F of the air-fuel T becomes higher, the SOx can be continuously absorbent 18, that is the exhaust gas temperature as shown in Fig. 13, as the temperature of the SO_x released from the SOx absorbent 18. At this time, (Kt = Ko), and at this time, the SO_x is continuously maintained at a relatively small degree of richness air-fuel mixture is made very rich (Kt = KK), it is On the other hand, after the air-fuel ratio of the

Note that, as the amount of the SO_x released from the SO_x absorbent 18 is larger when the sirfuel ratio of the air-fuel mixture is maintained rich (Kt = Ko), a time until the SO_x absorbent 18 terminates the release of SO_x becomes shorter. As mentioned before, as the exhaust gas temperature SO_x becomes faster, and the releasing speed of SO_x becomes faster, and the releasing speed of SO_x becomes faster, and accordingly, as shown in SO_x becomes faster, and sccordingly, as shown in SO_x becomes faster, and sccordingly, as shown in made rich to when it is returned to lean again is made shorter as the exhaust gas temperature T becomes higher. Note that, a relationship between

correction coefficient KK becomes gradually smallrection coefficient KK. Accordingly, the value of the predetermined value a is subtracted from the corcessing routine goes to step 420, at which the smaller than the time C_{2} . When $C < C_{2}$, the prodetermined whether or not the count value C is

cient is maintained at 1.0. time of the releasing of NOx, the correction coefficoefficient is maintained at Ko (> 1.0), while at the at the time of the releasing of SOx, the correction Accordingly, after when KK becomes equal to Ko, routine goes to step 422, at which KK is made Ko. comes equal to or smaller than Ko, the processing processing cycle is completed, and when KK bebecome smaller than Ko. When KK > Ko, the whether or not the correction coefficient KK has Subsequently, at step 421, it is determined

428, the count value C is made zero. sorption 19 is made zero. Subsequently, at step amount Wn of the NOx absorbed in the NOx absorption 18 is made zero, and then at step 427, the smount Ws of the SOx absorbed in the SOx abstarted again. Subsequently, at step 425, the later, the combustion of the lean air-fuel mixture is SOx releasing flag is reset, as will be mentioned at which the SOx releasing flag is reset. When the been set, the processing routine goes to step 424, has been set. When the SOx releasing flag has determined whether or not the SOx releasing flag processing routine goes to step 423, at which it is that C becomes equal to or larger than C2, the Subsequently, when it is decided at step 419

428, the count value C is made zero. sorption 19 is made zero. Subsequently, at step amount Wn of the NOx absorbed in the NOx abstarted again. Subsequently, at step 427, the later, the combustion of the lean air-fuel mixture is NOx releasing flag is reset, as will be mentioned which the NOx releasing flag is reset. When the set, the processing routine goes to step 426, at decided that the SOx releasing flag has not been On the other hand, at step 423, when it is

mixture fed into the engine cylinder is made the when the time for which air-fuel ratio of the air-fuel to step 430, at which Wn is made zero. Namely, predetermined time to, the processing routine goes and when the state of K ≥ 1.0 continues for the mined time t1, the processing cycle is completed, state of K≥ 1.0 does not continue for the predetermined time t1, for example 10 seconds. When the the state of K ≥ 1.0 continues for the predeterstep 429, at which it is determined whether or not tuel ratio or rich, the processing routine goes to into the engine cylinder is the stoichiometric sirwhen the air-fuel ratio of the air-fuel mixture fed 50 that K is equal to or larger than 1.0, that is, On the other hand, when it is decided at step

routine goes to step 405.

Wno, the processing cycle is completed. absorbed by the NO_x absorbent 19. When Mn ≦ based on the maximum amount of NOx that can be amount Wso is for example about 30 percent the predetermined set amount Wno. This set absorbed in the NOx absorbent 19 is larger than mined whether or not the amount Wn of the NOx routine goes to step 411. At step 411, it is deterabsorbent 18. When Ws \le Wso, the processing smonut of SOx that can be absorbed by the SOx ble spont 30 bercent pased on the maximum smount Wso. This set up amount Wso is for exambent 18 is larger than the predetermined set up amount W of the SOx absorbed in the SOx absor-At step 405, it is determined whether or not the

ratio of air-fuel mixture is made rich. calculated, as will be mentioned later, the air-fuel set and various values KK, C1, Ko, and C2 are pleted. Note that, when the SOx releasing flag is 18D. Subsequently, the processing cycle is com-C2 is calculated from the relationship shown in Fig. shown in Fig. 18C, and then at step 410, the time efficient KK is calculated from the relationship 18B. Subsequently, at step 409, the correction co-C₁ is calculated from the relationship shown in Fig. shown in Fig. 18A, and then at step 408, the time efficient KK is calculated from the relationship set. Subsequently, at step 407, the correction cogoes to step 406, at which the SOx releasing flag is stop 405 that Ws > Wso, the processing routine On the other hand, when it is determined at

ratio of air-fuel mixture is made rich. calculated, as will be mentioned later, the air-fuel is set and various values KK, C1, Ko, and C2 are completed. Note that, when the NOx releasing flag Fig. 16C. Subsequently, the processing cycle is time C2 is calculated from the relationship shown in efficient Ko is made 1.0, and then at step 416, the 16B. Subsequently, at step 415, the correction co-Ct is calculated from the relationship shown in Fig. shown in Fig. 16A, and then at step 414, the time efficient KK is calculated from the relationship set. Subsequently, at step 413, the correction cogoes to step 412, at which the NOx releasing flag is Wn > Wno at step 411, the processing routine On the other hand, when it is determined that

processing routine goes to step 419, at which it is when C becomes equal to or larger than C1, the tained at KK as it is for the time C1. Subsequently, and accordingly the correction coefficient is main-When $C < C_1$, the processing cycle is completed, not the count value C is smaller than the time C1. sequently, at step 418, it is determined whether or count value C is incremented exactly by one. Substep 403 or step 404 to step 417, at which the ing flag is set, the processing routine goes from When the SO_x releasing flag or the NO_x releas-

On the other hand, when the SO_x releasing flag or the NO_x releasing flag is set, the processing routine goes from step 502 or step 503 to step 504, at which Kt is made KK calculated by the routine shown in Fig. 20 and Fig. 21. Subsequently, the processing routine passes step 506, and the basic fuel injection time TAU is calculated at step basic fuel injection time TAU is calculated at step 507. Accordingly, at this time, the air-fuel ratio of the air-fuel mixture is forcibly made rich.

Figure 23 shows a still further embodiment. Note that, in this embodiment, the same constituent elements as those shown in Fig. 1 and Fig. 12 are indicated by the same symbols.

portion of the bypass passage 24 is fully opened to the NOx absorbent 19 is closed and the inlet a bypass opening position at which the inlet portion opened as indicated by the solid line in Fig. 23 and villut si et inedroeds xON ent of noitrog telni bortion of the bypass passage 24 is closed and the perween a bypass closed position at which the inlet 27 is controlled by the actuator 26 to either position inlet portion 20a of the casing 20. This switch valve branch portion of the bypass passage 24 from the controlled by an actuator 26 is arranged at the outlet portion of the casing 20. A switch valve 27 connected to the exhaust pipe 25 connected to the the casing 20, and this bypass passage 24 is sage 24 is branched from the inlet portion 20a of containing the NOx absorbent 19. A bypass pasconnected via the exhaust pipe 17 to the casing 20 bent 18, and the outlet portion of the casing 23 is fold 16 to the casing 23 containing the SOx absorexhaust port 8 is connected via the exhaust mani-Referring to Fig. 23, in this embodiment, the

as indicated by a broken line of Fig. 23.

Also, in this embodiment, a pressure sensor 28 generating an output voltage in proportion to the absolute pressure in the surge tank 10, and the output to the interior of the surge tank 10, and the output voltage of this pressure sensor 28 is input to the voltage of this pressure sensor 28 is input to the

input port 35 via the AD converter 37.

Also in this embodiment, the fuel injection time TAU is calculated based on for example the following equation.

 $A \cdot T = UAT$

Here, TP indicates the basic fuel injection time, and K indicates the correction coefficient. The basic fuel injection time TP indicates a fuel injection time necessary for making the air-fuel ratio of the air-fuel mixture fed into the engine cylinder the soir-fuel mixture fed into the engine cylinder the stoichiometric sir-fuel ratio. This basic fuel injection atoichiometric sir-fuel ratio. This basic fuel injection stoichiometric sir-fuel ratio. This basic fuel injection atoichiometric sir-fuel ratio. The ROM 32 in the form of a stoichiometric sir-fuel ratio. 24 as the functions of the absolute pressure PM of the surge tank 10 exabolute pressure PM of the surge tank 10 expecting the engine load and the engine rotational pressing the engine load and the engine rotational

stoichiometric sir-fuel ratio or rich continues for about 10 seconds, it is considered that the most part of the NO_x absorbed in the NO_x absorbent 19 was released, and accordingly, in this case, Wn is made zero at step 430.

Subsequently, at step 431, it is determined whether or not the state of K > 1.0 continues for the predetermined time t_2 ($t_2 > t_1$), for example, 10 minutes. When the state of K > 1.0 does not continue for the predetermined time t_2 , the processing cycle is completed, and when the state of K > 1.0 continues for the predetermined time t_2 , the processing routine goes to step 432, at which Ws processing routine goes to step 432, at which We is made zero. Namely, when the time for which sirtuel ratio of the air-fuel mixture fed into the engine cylinder is made rich continues for about 10 minutes, it is considered that the most part of the SO_x absorbent 18 was released, shootbed in the SO_x absorbent 18 was released, sand accordingly, in this case, Ws is made zero at step 432.

Figure 22 shows the calculation routine of the basic fuel injection time TAU, which routine is repeatedly executed.

Referring to Fig. 22, first of all, at step 500, the correction coefficient K is made for example 0.6 at the time of an operation state when the lean air-fuel mixture should be burned. Also, this correction coefficient K has become the function of the engine coefficient K has become the time of the engine coolant temperature at the time of the engine engine coolant temperature becomes higher within a range where K ≥ 1.0. Also, at the time of acceleration operation, this correction coefficient is arange where K ≥ 1.0. Also, at the time of acceleration operation, this correction coefficient is made 1.0, and at the time of full load operation, this correction coefficient K is made a larger value.

in accordance with the correction coefficient K. ratio of the air-fuel mixture is made the air-fuel ratio been set even when K≥ 1.0 or K < 1.0, the air-fuel the SOx releasing flag nor NOx releasing flag has TP • Kt) is calculated. Accordingly, when neither of at step 507, the basic fuel injection time TAU (= calculated from the map shown in Fig. 2, and then at step 506, the basic fuel injection time TP is processing routine goes to step 505. Subsequently, When the NOx releasing flag has not been set, the whether or not the NOx releasing flag has been set. routine goes to step 503, at which it is determined SOx releasing flag has not been set, the processing not the SOx releasing flag has been set. When the to step 502, at which it is determined whether or to this, when K < 1.0, the processing routine goes goes to step 505, at which K is made Kt. Contrary er than 1.0. When K ≥ 1.0, the processing routine whether or not the correction coefficient K is small-Subsequently, at step 501, it is determined

onto the platinum Pt in the form of SO_3^{2-} , and thus the SO_2 becomes easily absorbed into the absorbent in the form of the sulfuric acid ion SO_4^{2-} . Accordingly, so as to promote the absorption of the SO_2 , preferably the platinum Pt is carried on the carrier of the SO_2 , absorbent 18.

the SOx absorbent 18. absorbent 19, and the SOx releasing rate g(Kt) from 1.0), the NO_x releasing rate f(Kt) from the NO_x Kt = 1.0, rich when Kt > 1.0, and lean when Kt <injection time TP (stoichiometric air-fuel ratio when tion coefficient Kt with respect to the basic fuel Fig. 26B shows a relationship between the correcleasing rate g(T) from the SOx absorbent 18, and to trom the NO_x absorbent 19, and the SO_x reabsorbent 19 is made rich, the NOx releasing rate gas flowing into the SOx absorbent 18 and the NOx absorbent 18 when the air-fuel ratio of the exhaust perature T of the NOx absorbent 19 and the SOx Figure 26A shows a relationship between the tem-SOx absorbent 18 referring to Figs. 26A and 26B. bent 19 and the SOx releasing function from the of the NO_x releasing function from the NO_x absor-Next, a detailed explanation will be made again

comes higher. becomes higher, the NOx releasing rate f(Kt) berichness of the air-fuel ratio of the exhaust gas coefficient Kt becomes larger, that is, the degree of shown in Fig. 26B, as the value of the correction NOx releasing rate f(T) becomes higher, and as T of the NOx absorbent 19 becomes higher, the Note that, as shown in Fig. 26A, as the temperature NOx absorbent 19 at a considerably high speed. Mamely, this means that NOx is released from the MOx releasing rate f(T) becomes considerably high. of the NO_x absorbent 19 is considerably low, the ingly, as shown in Fig. 26A, even if the temperature immediately released from the absorbent. Accordto the direction of (NO_3^- , -> NO_2), and the NO_x is longer exists, the reaction is immediately advanced when the NO₂ on the surface of the platinum Pt no of the NOx absorbent 19 is almost 150°C or more, In the NO_x absorbent 19, when the temperature

Contrary to this, the SO_x absorbed in the SO_x absorbent 18 is stable in comparison with the MO_x absorbent 19, and therefore is absorbed in the MO_x absorbent 19, and therefore is difficult to be decomposed, and the decomposition of this SO_x is not sufficiently caused unless the temperature T of the SO_x absorbent 18 exceeds the temperature To determined accordingly, as shown in Fig. 26A, when the temperature T of the so_x absorbent 18 is lower than To, the SO_x released from the SO_x absorbent 18 is lower than To, the SO_x released from the SO_x absorbent 18, and it so_x in released from the SO_x absorbent 18, and it so_x is released from the SO_x absorbent 18 extremely low, that is, almost no so_x is released from the SO_x absorbent 18 extremestructure T of the SO_x absorbent 18 is substantially started. Note that, the temperature T of the SO_x absorbent 18 is substantially started. Note that,

speed N. The correction coefficient K is a coefficient for controlling the sir-fuel ratio of the sir-fuel mixture fed into the engine cylinder, and if K=1.0, the sir-fuel ratio of the sir-fuel mixture fed into the engine cylinder becomes the stoichiometric sirtuel ratio. Contrary to this, when K becomes smaller than 1.0, the sir-fuel ratio of the sir-fuel mixture fed into the engine cylinder becomes larger than tatio of the sir-fuel ratio, that is, becomes lean, and if K becomes larger than 1.0, the sir-fuel lean, and if K becomes larger than 1.0, the sir-fuel engine cylinder becomes larger than 1.0, the sir-fuel lean, and if K becomes larger than 1.0, the sir-fuel sir-fuel mixture fed into the engine ratio of the sir-fuel mixture fed into the engine cylinder becomes smaller than the stoichiometric sir-fuel ratio, that is, becomes rich.

be burned. of the operation period, the lean air-fuel mixture will tion is the highest, and accordingly in the most part slly the frequency of low and medium load operamade rich. In the internal combustion engine, usuthe air-fuel mixture fed into the engine cylinder is and accordingly, at this time, the air-fuel ratio of tion coefficient K is made a value larger than 1.0, full load operation region, the value of the correctank 10 becomes the highest, that is, in the engine which the absolute pressure PM inside the surge stoichiometric air-fuel ratio. Also, in a region in mixture ted into the engine cylinder is made the ingly, at this time, the air-fuel ratio of the air-fuel correction coefficient K is made 1.0, and accordengine high load operation region, the value of the the surge tank 10 is relatively high, that is, in the region in which the absolute pressure PM inside cylinder is made lean. On the other hand, in a ratio of the air-fuel mixture fed into the engine than 1.0, and accordingly, at this time, the air-fuel correction coefficient K is made a value smaller or medium load operation region, the value of the tank 10 is relatively low, that is, in the engine low which the absolute pressure PM inside the surge the embodiment shown in Fig. 25, in a region in n.ent of the value of this correction coefficient K. In rotational speed N, and Fig. 25 shows one embodipressure PM in the surge tank 10 and the engine determined in advance with respect to the absolute The value of this correction coefficient K is

Also in this embodiment, as the SO_x absorbent 18, use is made of an absorbent which carries at least one member selected from a transition metal such as copper Cu, iron Fe, manganese Mn, and inckel Mi, sodium Ma, tin Sn, titanium Ti, and lithing Li on a carrier made of alumina. Note that, in this SO_x absorbent 18, as mentioned before, when the air-fuel ratio of the exhaust gas flowing into the akhaust gas is oxidized on the surface of the absorbent while absorbed into the absorbent in the form of sulfuric acid ion SO_x^{2-} , and in this case, form of sulfuric acid ion SO_x^{2-} , and in this case, form of sulfuric acid ion SO_x^{2-} , and in this case, SO_x absorbent 18, SO_x becomes easily adhered SO_x absorbent 18, SO_x becomes easily adhered SO_x absorbent 18, SO_x becomes easily adhered

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also for SO_x , when the temperature T of the SO_x absorbent 18 exceeds To, as shown in Fig. 26A, as the temperature T of the SO_x absorbent 18 becomes higher, the SO_x releasing rate g(T) becomes higher, and as shown in Fig. 26B, as the value of the correction coefficient Kt becomes larger, the SO_x releasing rate g(kt) becomes higher.

Figure 27A shows the cumulative NO_x release from the NO_x absorbent 19 and the cumulative SO_x release from the SO_x absorbent 18 when the airfuel ratio of the inflowing exhaust gas to the NO_x absorbent 19 and the SO_x absorbent 18 is made rich when the temperature T of the NO_x absorbent 19 and the SO_x absorbent 18 is lower than To (Fig. 26A); and a solid line of Fig. 27B shows the cumulative NO_x release from the NO_x absorbent 19 and the cumulative SO_x release from the SO_x absorbent 18 When the air-fuel ratio of the inflowing exhaust gas to the NO_x absorbent 19 and the SO_x absorbent 18 is made rich when the temperature T of the NO_x absorbent 19 and the SO_x absorbent 18 is higher than To (Fig. 26A).

When the temperature T of the SO_x absorbent 18 is lower than To, as shown in Fig. 26A, almost no SO_x is released, and accordingly, at this time, when the air-fuel ratio of the exhaust gas flowing into the NO_x absorbent 19 and the SO_x absorbent 18 is made rich, as shown in Fig. 27A, the NO_x is quickly released from the NO_x absorbent 19, but almost no SO_x is released from the SO_x absorbent 18.

On the other hand, when the temperature T of the SO_x absorbent 18 becomes higher than To, as shown in Fig. 26A, the SO_x releasing function is carried out, and therefore, at this time, if the air-fuel ratio of the exhaust gas flowing into the the NO_x absorbent 19 and the SO_x absorbent 18 is made rich, as indicated by the solid line in Fig. 27B, both of the NO_x and SO_x are released. In this case, the NOx is released from the NOx absorbent 19 in a short time, but the decomposition rate of SOx inthe SO_x absorbent 18 is low, and therefore the SO_x is released from the SO_x absorbent 18 only slowly. Note that, also in this case, when the temperature T of the SO_x absorbent 18 becomes high, as seen from Fig. 26A, the SO_x releasing rate g(T) becomes high, and therefore, as indicated by a broken line in Fig. 27B, the SO_x is released from the SO_x absorbent 18 relatively fast.

Also, the $\mathrm{NO_x}$ release indicated by the solid line in Fig. 27B shows the $\mathrm{NO_x}$ release from the $\mathrm{SO_x}$ absorbent 18 in which a transition metal such as copper Cu, iron Fe, manganese Mn, nickel Ni, or the like, sodium Na, or lithium Li or the like is carried on the carrier made of alumina, and in the $\mathrm{SO_x}$ absorbent 18 in which for example titania $\mathrm{TiO_2}$ is carried on a carrier made of alumina, as indicated by the broken line in Fig. 27B, $\mathrm{SO_x}$ is

released from the SO_x absorbent 18 relatively fast. In this way the SO_x releasing speed from the SO_x absorbent 18 changes also according to the type of the SO_x absorbent 18, and changes also according to the temperature T of the SO_x absorbent 18.

As mentioned before, if the air-fuel ratio of the exhaust gas flowing into the the SO_x absorbent 18 and the NOx absorbent 19 is made rich when the temperature T of the SO_x absorbent 17 is higher than To, the SOx is released from the SOx absorbent 18, and the NO_x is released from the NO_x absorbent 19. At this time, if the exhaust gas flowing out from the SOx absorbent 18 is made to flow into the NO_x absorbent 19, as mentioned before, the SO_x released from the SO_x absorbent 18 is absorbed into the NOx absorbent 19. Therefore, in this embodiment, so as to prevent the SOx released from the SOx absorbent 18 from absorption into the NOx absorbent 19 in this way, when the SOx absorbent 18 should release the SOx, the exhaust gas flowing out of the SOx absorbent 18 is guided into the bypass passage 24.

Namely, in this embodiment, when the lean airfuel mixture is burned, the switch valve 27 is held at the bypass closed position indicated by the solid line in Fig. 23, and accordingly, at this time, the exhaust gas flowing out of the SOx absorbent 18 flows into the NOx absorbent 19. Accordingly, at this time, the SO_x in the exhaust gas is absorbed by the SO_x absorbent 18, and therefore only the NO_x is absorbed into the NO_x absorbent 19. Subsequently, when the SO_x from the SO_x absorbent 18 should be released, as shown in Fig. 28, the airfuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from lean to rich, and simultaneously the switch valve 27 is switched to the bypass opening position indicated by the broken line in Fig. 23. When the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes rich, as shown in Fig. 28, SO_x is released from the SOx absorbent 18, but at this time, the flowing out exhaust gas from the SO_x absorbent 18 does not flowing into the NOx absorbent 19, but flows into the bypass passage 24.

Subsequently, when the releasing action of the SO_x should be stopped, the air-fuel ratio of the air-fuel ratio of the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from rich to lean, and simultaneously the switch valve 27 is switched to the bypass closed position indicated by the solid line in Fig. 23. When the air-fuel ratio of the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes lean, as shown in Fig. 28, the releasing action of SO_x from the SO_x absorbent 18 is stopped.

In this way, in the embodiment shown in Fig. 28, when the SO_x is being released from the SO_x absorbent 18, the exhaust gas flowing out of the

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 SO_x absorbent 18 flows into the bypass passage 24, and therefore it becomes possible to prevent the SO_x from absorption into the NO_x absorbent 19. Note that, at this time, the unburnt HC and CO and NO_x are discharged from the engine, but as mentioned before, the SO_x absorbent 18 has a three-way catalytic function, and therefore these unburnt HC and CO and NO_x are considerably removed at the SO_x absorbent 18, and accordingly, at this time, there is no risk of releasing of a large amount of unburnt HC and CO and NO_x into the atmosphere.

Figure 29 and Fig. 30 show respectively different embodiments in which when the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich so as to release the SO_x from the SO_x absorbent 18, the releasing action of the NO_x from the NO_x absorbent 19 is carried out together with the former.

The embodiment shown in Fig. 29 shows the SO_x and NO_x releasing control which can be applied to a case where the SO_{κ} releasing speed from the SOx absorbent 18 is considerably slower in comparison with the NOx releasing speed from the NO_x absorbent 19. As indicated by the solid line in Fig. 27B, where the SO_x releasing speed is slower in comparison with the NOx releasing speed, when the air-fuel ratio of the exhaust gas flowing into the the SO_x absorbent 18 and the NO_x absorbent 19 is switched from lean to rich, the NO_x is released from the NOx absorbent 19 in a short time, and in addition during a time when the releasing action of NOx is carried out, almost no SOx is released from the SO_x absorbent 18. Accordingly, in this embodiment, during a predetermined period after when the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from lean to rich (Kt = KK1) (a period for which Kt = KK1 is maintained in Fig. 29), the switch valve 27 is held at the bypass closed position, and then when this predetermined period has elapsed, the switch valve 27 is switched to the bypass opening position. For the predetermined period after this (period for which Kt = KK2 is maintained), the airfuel ratio of the air-fuel mixture fed into the combustion chamber 3 is maintained rich (Kt = KK2). and when this predetermined period has elapsed. the switch valve 27 is switched to the bypass closed position.

In this way, in this embodiment, in an initial stage when the air-fuel ratio of the air-fuel mixture is switched from lean to rich, the switch valve 27 is held at the bypass closed position, and therefore the NO_x is rapidly released from the NO_x absorbent 19. At this time, the releasing of the SO_x is started also from the SO_x absorbent 18, but the release of SO_x is small, and accordingly, even if this SO_x is absorbed into the NO_x absorbent 19, the amount of

absorption of SO_x is not so much increased. The most part of the SO_x is released from the SO_x absorbent 18 after the switch valve 27 is switched to the bypass closed position, and accordingly the most part of the SO_x is fed into the bypass passage 24.

The embodiment shown in Fig. 30 shows the SOx and NOx releasing control controlled so as to prevent the SOx from absorption into the NOx absorbent 19 as much as possible. In this embodiment, when the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, the switch valve 27 is switched to the bypass closed position. At this time, the releasing of the SOx is started from the SOx absorbent 18, and this SO_x is all fed into the bypass passage 24. Subsequently, when the releasing action of the SOx from the SOx absorbent 18 is almost completed, the switch valve 27 is switched to the bypass closed position while maintaining the air-fuel ratio of the air-fuel mixture rich. When the switch valve 27 is switched to the bypass closed position, the NO. israpidly released from the NOx absorbent 19, and when the releasing action of NOx from the NOx absorbent 19 is completed, the air-fuel ratio of the air-fuel mixture is switched from rich to lean.

In this embodiment, after the SO_x releasing action from the SO_x absorbent 18 is completely terminated, if the switch valve 27 is switched from the bypass opening position to the bypass closed position, it is possible to completely prevent the SO_x from absorption into the NO_x absorbent 19.

Note that, even in a case where the releasing speed of the SO_x from the SO_x absorbent 18 is slow as indicated by the solid line in Fig. 27B, when the temperature of the SO_x absorbent 18 becomes high, as mentioned before, the SO, releasing speed becomes faster. In this way, when the SO_x and NO_x releasing action as shown in Fig. 29 is carried out when the SOx releasing speed becomes faster, immediately after the air-fuel ratio of the air-fuel mixture is switched from lean to rich, a large amount of the SO_x is released also from the SO_x absorbent 18, and thus a large amount of the SO_x becomes absorbed into the NO_x absorbent 19. Therefore, in another embodiment according to the present invention, when the temperature of the SO_x absorbent 18 is relatively low and the releasing speed of SO_x is slow, the releasing control of the SOx and NOx shown in Fig. 29 is carried out, and when the temperature of the SO_x absorbent 18 becomes high and the releasing speed of SOx becomes faster, the releasing control of the SOx and NO_x shown in Fig. 30 is carried out.

Figure 31 shows the releasing control timing of the NO_x and SO_x . Note that, this Fig. 31 shows a case using the embodiment shown in Fig. 29 as the SO releasing control. Also, in Fig. 31, P in-

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dicates the NO_x releasing control, and Q indicates the NO_x and SO_x releasing control.

In the embodiment shown in Fig. 31, the releasing processing of the NO_x and SO_x is carried out based on the NO_x amount Wn and the SO_x amount Ws. In this case, as the amount Wn of NO_x absorbed in the NO_x absorbent 19 and the amount Ws of SO_x absorbed in the SO_x absorbent 18, an estimated absorption amount estimated from the operation state of the engine is used. This NO_x amount Wn and SO_x amount SO_x will be mentioned later.

As shown in Fig. 31, when the NO_x amount Wn exceeds the maximum allowable value Wno, the air-fuel ratio of the air-fuel mixture is made rich (Kt = KK1), and the releasing action of NO_x from the NO_x absorbent 19 is started. When the releasing action of NOx is started, the NOx amount Wn is rapidly reduced, and when the NOx amount Wn reaches the lower limit value MIN, the air-fuel ratio of the air-fuel mixture is switched from rich to lean, and the releasing action of NOx is stopped. Contrary to this, when the SOx amount Sn exceeds the maximum allowable value Wso, the air-fuel ratio of the air-fuel mixture is made rich (Kt = KK1) for a predetermined period, and the releasing action of $NO_{\mathbf{x}}$ from the $NO_{\mathbf{x}}$ absorbent 19 is started. At this time, also the releasing action of SOx from the SOx absorbent 18 is started. Subsequently, when the NO_x amount Wn reaches the lower limit value MIN; the switch valve 27 is switched to the bypass opening position. Subsequently, when the SO_x amount Ws reaches the lower limit value MIN, the air-fuel ratio of the air-fuel mixture is switched from rich to lean, and the releasing action of SOx is stopped.

Note that, as seen from Fig. 31, the period of making the air-fuel ratio of the air-fuel mixture rich so as to release the NOx from the NOx absorbent 19 is considerably short, and the air-fuel ratio of the air-fuel mixture is made rich with a proportion of one time per several minutes. On the other hand, as mentioned before, the amount of SO_x contained in the exhaust gas is considerably smaller than the amount of NOx, and therefore a considerably long time is taken until the SOx absorbent 18 is saturated by the SO_x. Accordingly, the period of making the air-fuel ratio of the air-fuel mixture rich so as to release the SOx from the SOx absorbent 18 is considerably short, and the air-fuel ratio of the air-fuel mixture is made rich with a proportion of for example one time per several hours.

Figures 32A to 32D show the flag switch valve control routine for executing the NO_x and SO_x releasing control shown in Fig. 28, which routine is executed by the interruption at every predetermined time interval.

Referring to Figs. 32A to 32D, first of all, at step 600 to step 608, the amount Wn of NO_x absorbed in the NO_x absorbent 19 and the amount Ws of SO_x absorbed in the SO_x absorbent 18 are calculated. Namely, first of all, at step 600, it is determined whether or not the correction coefficient Kt with respect to the basic fuel injection time TP is smaller than 1.0. When Kt < 1.0, that is, when the lean air-fuel mixture is fed into the combustion chamber 3, the processing routine goes to step 601, at which the NO_x amount Wn is calculated based on the following equation, and then the SO_x amount Ws is calculated based on the following equation.

$$Wn = Wn + K_1 \cdot N \cdot PM$$

$$Ws = Ws + K_2 \cdot N \cdot PM$$

Here, N indicates the engine rotational speed; PM indicates the absolute pressure in the surge tank 10; and K1 and K2 indicate constants (K1 > K₂). The amount of the NO_x and amount of SO_x discharged from the engine per unit time are in proportion to the engine rotational speed N and in proportion to the absolute pressure PM in the surge tank 10, and therefore the NO_x amount Wn and the SO, amount Ws are represented as in the above equations. Accordingly, it is seen from these equations that so far as the combustion of the lean air-fuel mixture is continued, the NOx amount Wn and the SOx amount Ws are increased. When the NO_x amount Wn is calculated at step 601, and the SO_x amount Ws is calculated at step 602, the processing routine goes to step 609.

On the other hand, when it is determined at step 600 that $\mathrm{Kt} \geq 1.0$, that is, when air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is the stoichiometric air-fuel ratio or rich, the processing routine goes to step 603, at which the $\mathrm{NO_x}$ amount Wn is calculated based on the following equation, and then the processing routine goes to step 604, at which the $\mathrm{SO_x}$ amount Ws is calculated based on the following equation:

$$Wn = Wn - Wn \cdot f(T) \cdot f(Kt)$$

 $Ws = Ws - Ws \cdot g(T) \cdot g(Kt)$

Here, f(T) and g(T) indicate the NO_x releasing rate and the SO_x releasing rate shown in Fig. 26A, respectively, and f(Kt) and g(Kt) indicate the NO_x releasing rate and the SO_x releasing rate shown in Fig. 26B, respectively. As shown in Fig. 26A, the NO_x releasing rate f(T) and the SO_x releasing rate g(T) are functions of the exhaust gas temperature T, and accordingly these NO_x releasing rate f(T) and SO_x releasing rate g(T) are calculated from the exhaust gas temperature T detected by the tem-

perature sensor 22. Note that, it is also possible to directly detect the exhaust gas temperature T by the temperature sensor 22 in this way, but it is also possible to estimate the same from the absolute pressure PM in the surge tank 10 and the engine rotational speed N. In this case, it is sufficient if the relationship among the exhaust gas temperature T, the absolute pressure PM, and the engine rotational speed N is found in advance by experiments, this relationship is stored in advance in the ROM 32 in the form of the map as shown in Fig. 33, and the exhaust gas temperature T is calculated from this map.

Also, as shown in Fig. 26B, the NOx releasing rate f(Kt) and SOx releasing rate g(Kt) are functions of the correction coefficient Kt, and accordingly the NO_x releasing rate f(Kt) and SO_x releasing rate g-(Kt) are calculated from the correction coefficient Kt. An actual NOx releasing rate is expressed by the product of the f(T) and the f(Kt), and therefore this means that the amount of NOx released from the NO_x absorbent 19 per unit time is expressed by Wn • f(T) • f(Kt), and accordingly the amount Wn of NO_x absorbed in the NO_x absorbent 19 becomes like the above-mentioned equation. Similarly, the SOx releasing rate is expressed by the product of the g(T) and the g(Kt), and therefore this means that the amount of SOx released from the SOx absorbent 18 per unit time is expressed by Ws • g(T) • g(Kt), and accordingly the amount Ws of SO_x absorbed in the SO_x absorbent 18 becomes like the above-mentioned equation. Accordingly, it is seen that both of the NOx amount Wn and the SO_x amount Ws are reduced when Kt ≥ 1.0. Note that, the NOx amount Wn and the SOx amount Ws calculated at step 601 to step 604 is stored in the backup RAM 33a.

When the NO_x amount Wn is calculated at step 603 and the SO_x amount Ws is calculated at step 604, the processing routine goes to step 605, at which it is determined whether or not the NO_x amount Wn becomes negative. When Wn < 0, the processing routine goes to step 606, at which Wn is made zero, and then the processing routine goes to step 607. At step 607, it is determined whether or not the SO_x amount Ws becomes negative. When Ws < 0, the processing routine goes to step 608, at which Ws is made zero, and then the processing routine goes to step 609.

At step 609, it is determined whether or not the correction coefficient K determined according to the engine rotation state shown in Fig. 25 is smaller than 1.0. When K < 1.0, that is, when the target airfuel ratio determined according to the operation state of the engine is lean, the processing routine goes to step 610, at which it is determined whether or not the SO_x processing has been set. When the SO_x processing flag has not been set, the routine

jumps to step 613, at which it is determined whether or not the SO_x releasing flag has been set. When the SO_x releasing flag has not been set, the processing routine goes to step 614, at which it is determined whether or not the NO_x releasing flag has been set. When the NO_x releasing flag has not been set, the processing routine goes to step 615.

At step 615, it is determined whether or not the SO_x amount Ws has become larger than the maximum allowable value Wso (Fig. 31). When Ws \leq Wso, the processing routine goes to step 616, at which it is determined whether or not the NO_x amount Wn has become larger than the maximum allowable value Wno. When Wn \leq Wno, the processing cycle is completed. At this time, the lean air-fuel mixture is fed into the combustion chamber 3, and the switch valve 27 is held at the bypass closed position.

On the other hand, when it is determined at step 616 that the Wn becomes larger than Wno, the processing routine goes to step 617, at which the NOx releasing flag is set, and then the processing cycle is completed. In the next processing cycle, it is determined at step 614 that the NOx releasing flag has been set, and therefore the processing routine goes to step 618, at which the correction coefficient Kt is made KK1. The value of this KK1 is a value of about 1.1 to 1.2 with which the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes about 12.0 to 13.5. When Kt is made KK1, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich. Subsequently, at step 619, it is determined whether or not the NOx amount Wn has become smaller than the lower limit value MIN (Fig. 31), and when Wn ≥ MIN, the processing cycle is completed. Contrary to this, when Wn becomes smaller than MIN, the processing routine goes to step 620, at which the NOx releasing flag is set. When the NOx releasing flag is reset, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from rich to lean. Accordingly, during a period from when Wn becomes larger than Wno to when Wn becomes smaller than MIN, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, and during this time, the NOx is released from the NOx absorbent 19.

On the other hand, when it is decided at step 615 that the SO_x amount Ws has become larger than the maximum allowable value Wso, the processing routine goes to step 621, at which it is determined whether or not the temperature T of exhaust gas flowing into the SO_x absorbent 18 is higher than the set value To (Fig. 26A). When T \leq To, the processing cycle is completed. Contrary to this, when T > To, the processing routine goes to step 622, at which the SO_x releasing flag is set and

then the processing cycle is completed.

In the next processing cycle, it is decided at step 613 that the SOx releasing flag has been set, and therefore the processing routine goes to step 623, at which the correction coefficient Kt is made KK2. The value of this KK2 is the value of about 1.1 to 1.2 with which the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes about 12.0 to 13.5. It is also possible to make the value of this KK2 different from the value of KK1, and make the same as the same value as the value of KK1. When the correction coefficient Kt is made KK2, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich. Subsequently, at step 624, the switch valve 27 is switched to the bypass opening position, and thus the exhaust gas flowing out of the SO_x absorbent 18 is fed into the bypass passage 24.

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Subsequently, at step 625, it is determined whether or not the SO, amount Ws has become smaller than the lower limit value MIN, and when Ws ≥ MIN, the processing cycle is completed. Contrary to this, when Ws becomes smaller than MIN, the processing routine goes to step 626, at which the switch valve 27 is switched to the bypass closed position, and then the processing routine goes to step 627, at which the SO_x releasing flag is reset. When the SOx releasing flag is reset, the airfuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from rich to lean. Accordingly, when Ws becomes larger than Wso, if T > To, from when the Ws becomes larger than Wso to when Ws becomes smaller than MIN, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich and, at the same time, the switch valve 27 is held at the bypass opening position. Thus, during this term, the SO_x is released from the SO_x absorbent 18, and the released SOx is fed into the bypass passage 24.

On the other hand, when it is determined at step 609 that K ≥ 1.0, that is, when the target airfuel ratio of the air-fuel mixture which should be fed into the combustion chamber 3 becomes the stoichiometric air-fuel ratio or rich, the processing routine goes to step 628, at which the NOx releasing flag is reset, and then the processing routine goes to step 629, at which the SOx releasing flag is reset. Subsequently, at step 630, the switch valve control shown in Fig. 32D is carried out. In this switch valve control, as shown in Fig. 32D, first of all, it is determined at step 631 whether or not the SO_x processing flag has been set. When the SO_x flag has not been set, the processing routine goes to step 632, at which it is determined whether or not the SOx amount Ws is larger than the set up value Wk (MIN < Wk < Wso). When Ws ≤ Wk, the processing routine goes to step 634, at which the switch valve 27 is made the bypass closed position. When Ws \leq Wk even if the SO_x is released from the SO_x absorbent 18, since the SO_x release is small, the switch valve 27 is made the bypass closed position.

Contrary to this, when Ws > Wk, the processing routine goes to step 633, at which it is determined whether or not the temperature T of exhaust gas flowing into the SO_x absorbent 18 is higher than the set value To (Fig. 26A). When T \leq To, the processing routine goes to step 634. Namely, when T \leq To, almost no SO_x is released from the SO_x absorbent 18, and therefore the switch valve 27 is made the bypass closed position. Note that, the NO_x is released from the NO_x absorbent 19 when the switch valve 27 is held at the bypass closed position.

On the other hand, when it is decided at step 633 that T > To, the processing routine goes to step 635, at which the SO_x processing flag is set. When the SOx processing flag is set, the processing routine goes from step 631 to step 633, at which the switch valve 27 is switched to the bypass opening position. Namely, when Ws > Wk and T > To, a certain amount of SOx is released from the SOx absorbent 18, and therefore the switch valve 27 is made the bypass opening position so as to feed the released SOx into the bypass passage 24. Subsequently, at step 637, it is determined whether or not the amount Ws of SOx becomes smaller than the lower limit value MIN. When Ws becomes smaller than MIN, the processing routine goes to step 638, at which the SO_x processing flag is reset. When the SO_x processing flag is reset, in the next processing cycle, the processing routine goes from step 631 to step 632, since it is determined that Ws is equal to or smaller than Wk at this time, and therefore the processing routine goes to step 634, at which the switch valve 27 is switched to the bypass closed position.

On the other hand, where the SO_x flag has been set when the operation state is changed from the state where $K \ge 1.0$ to the state where K < 1.0, the processing routine goes from step 610 to step 611, at which the SO_x processing flag is reset. Subsequently, at step 612, the switch valve 27 is switched to the bypass closed position.

Figure 34 shows the calculation routine of the fuel injection time TAU, which routine is repeatedly executed.

Referring to Fig. 34, first of all, at step 650, the correction coefficient K determined in accordance with the engine operation state shown in Fig. 25 is calculated. Subsequently, at step 651, the basic fuel injection time TP is calculated from the map shown in Fig. 2. Subsequently, at step 652, it is determined whether or not the NO_x releasing flag

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has been set, and when the NO_x releasing flag has not been set, the processing routine goes to step 653, at which it is determined whether or not the SO_x releasing flag has been set. When the SO_x releasing flag has not been set, the processing routine goes to step 654, at which the correction coefficient K is made Kt, and then at step 655, the fuel injection time TAU (= $TP \cdot Kt$) is calculated by multiplying the basic fuel injection time TP by Kt. Accordingly, when the NO_x releasing flag and the SO_x releasing flag have not been set, the airfuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes the air-fuel ratio determined by the correction coefficient K.

Contrary to this, when the NO_x releasing flag is set, the processing routine jumps to step 655, and when the SO_x releasing flag is set, the processing routine goes to step 655. When the NO_x releasing flag is set, in the routine shown in Figs. 32A to 32D, Kt is made equal to KK1 (KK1 > 1.0), and therefore the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, while when the SO_x releasing flag is set, in the routine shown in Figs. 32A to 32D, Kt is made equal to KK2 (KK2 > 1.0), and therefore the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich.

Figures 35A to 35D show the flag switch valve control routine for executing the NO_x and SO_x releasing control shown in Fig. 29, which routine is executed by interruption at every predetermined time interval. Note that, in this embodiment, the flow chart part shown in Fig. 35A, Fig. 35B, and Fig. 35D is substantially the same as the flow chart part shown in Fig. 32A, Fig. 32B, and Fig. 32D, and the part which is basically different from them is only the flow chart part shown in Fig. 35C.

Namely, referring to Figs. 35A to 35D, first of all, at step 700, it is determined whether or not the correction coefficient Kt with respect to the basic fuel injection time TP is smaller than 1.0. When Kt < 1.0, that is, when the lean air-fuel mixture is fed into the combustion chamber 3, the processing routine goes to step 701, at which the NO_x amount Wn (= Wn + K₁ • N • PM) is calculated, and then the processing routine goes to step 702, at which the SO_x amount Ws (= Ws + K₂ • N • PM) is calculated. Here, N indicates the engine rotational speed, P indicates the absolute pressure in the surge tank 10, and K₁ and K₂ indicate constants (K₁ > K₂). Then, the processing routine goes to step 709.

On the other hand, when it is determined at step 700 that $Kt \ge 1.0$, that is, when the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is the stoichiometric air-fuel ratio or rich, the processing routine goes to step 703, at which the NO_x amount $Wn (= Wn - Wn \cdot f(T) \cdot f(T$

(Kt)) is calculated, and then the processing routine goes to step 704, at which the SO_x amount Ws (= Ws - Ws • g(T) • g(Kt)) is calculated. Here, f(T) and g(T) indicate the NO_x releasing rate and SO_x releasing rate shown in Fig. 26A, respectively, and f(Kt) and g(Kt) indicate the NO_x releasing rate and SO_x releasing rate shown in Fig. 26B, respectively

When the NO_x amount Wn is calculated at step 703, and the SO_x amount Ws is calculated at seep 704, the processing routine goes to step 705, at which it is determined whether or not the NO_x amount Wn has become negative. When Wn < 0, the processing routine goes to step 706, at which Wn is made zero, and then, the processing routine goes to step 707. At step 707, it is determined whether or not the SO_x amount Ws becomes negative. When Ws < 0, the processing routine goes to step 708, at which Ws is made zero, and then the processing routine goes to step 709.

At step 709, it is determined whether or not the correction coefficient K determined according to the engine operation state shown in Fig. 25 is smaller than 1.0. When K < 1.0, that is, when the target air-fuel ratio determined according to the operation state of the engine is lean, the processing routine goes to step 710, at which it is determined whether or not the SO_x processing has been set. When the SO_x processing flag has not been set, the routine jumps to step 713, at which it is determined whether or not the SOx and NOx releasing flag has been set. When the SO_x and NO_x releasing flag has not been set, the processing routine goes to step 714, at which it is determined whether or not the NO_x releasing flag has been set. When the NO_x releasing flag has not been set, the processing routine goes to step 715.

At step 715, it is determined whether or not the SO_x amount Ws has become larger than the maximum allowable value Wso (Fig. 31). When Ws \leq Wso, the processing routine goes to step 716, at which it is determined whether or not the NO_x amount Wn has become larger than the maximum allowable value Wno. When Wn \leq Wno, the processing cycle is completed. At this time, the lean air-fuel mixture is fed into the combustion chamber 3, and the switch valve 27 is held at the bypass closed position.

On the other hand, when it is determined at step 716 that the Wn becomes larger than Wno, the processing routine goes to step 717, at which the NO_x releasing flag is set, and then the processing cycle is completed. In the next processing cycle, it is determined at step 714 that the NO_x releasing flag has been set, and therefore the processing routine goes to step 718, at which the correction coefficient Kt is made KK1. The value of this KK1 is a value of about 1.1 to 1.2 with which the air-fuel ratio of the air-fuel mixture fed into the

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combustion chamber 3 becomes about 12.0 to 13.5. When Kt is made KK1, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich. Subsequently, at step 719, it is determined whether or not the NOx amount Wn has become smaller than the lower limit value MIN (Fig. 31), and when Wn ≥ MIN, the processing cycle is completed. Contrary to this, when Wn becomes smaller than MIN, the processing routine goes to step 720, at which the NOx releasing flag is set. When the NO_x releasing flag is reset, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from rich to lean. Accordingly, during a period from when Wn becomes larger than Wno to when Wn becomes smaller than MIN, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, and during this time, the NOx is released from the NOx absorbent 19.

On the other hand, when it is decided at step 715 that the SO_x amount Ws has become larger than the maximum allowable value Wso, the processing routine goes to step 721, at which it is determined whether or not the temperature T of exhaust gas flowing into the SO_x absorbent 18 is higher than the set value To (Fig. 26A). When T \leq To, the processing cycle is completed. Contrary to this, when T > To, the processing routine goes to step 722, at which the SO_x and NO_x releasing flag is set and then the processing cycle is completed.

In the next processing cycle, it is decided at step 713 that the SO_x and NO_x releasing flag has been set, and therefore the processing routine goes to step 723, at which it is determined whether or not the NOx amount Wn has become smaller than the lower limit value MIN. When Wn > MIN, the processing routine goes to step 724, at which the correction coefficient Kt is made KK1, and then the processing cycle is completed. Accordingly, when Ws becomes larger than Wso; the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich (Kt = KK1) until when Wn becomes smaller than MIN, and the switch valve 27 is held at the bypass closed position. Accordingly, the NOx will be released from the NOx absorbent 19 during this time.

On the other hand, when it is decided at step 723 that Wn becomes smaller than MIN, the processing routine goes to step 725, at which the correction coefficient Kt is made KK2. The value of this KK2 is a value of about 1.1 to 1.2 with which the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes about 12.0 to 13.5. It is also possible to make the value of this KK2 different from the value of KK1, or make this the same value as the value of KK1. When the correction coefficient Kt is made KK2, the air-fuel ratio of the air-fuel mixture fed into the combustion

chamber 3 is made rich. Subsequently, at step 726, the switch valve 27 is switched to the bypass opening position. Thus, the exhaust gas flowing out of the SO_x absorbent 18 is fed into the bypass passage 24.

Subsequently, at step 727, it is determined whether or not the SOx amount Ws becomes smaller than the lower limit value MIN, and when Ws ≥ MIN, the processing cycle is completed. Contrary to this, when Ws becomes smaller than MIN, the processing routine goes to step 728, at which the switch valve 27 is switched to the bypass closed position, and then the processing routine goes to step 729, at which the SOx and NOx releasing flag is reset. When the SOx and NOx releasing flag is reset, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from rich to lean. Accordingly, if T > To when Ws becomes larger than Wso, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich (K = KK2) from when Wn becomes smaller than MiN to when Ws becomes smaller than MIN and, at the same time, the switch valve 27 is made the bypass opening position. Thus, during this time, the SOx is released from the SOx absorbent 18, and the released SOx is fed into the bypass passage 24.

On the other hand, when it is determined at step 709 that K ≥ 1.0, that is, when the target airfuel ratio of the air-fuel mixture which should be fed into the combustion chamber 3 becomes the stoichiometric air-fuel ratio or rich, the processing routine goes to step 730, at which the NOx releasing flag is reset, and then the processing routine goes to step 731, at which the SOx and NOx releasing flag is reset. Subsequently, at step 732, the switch valve control shown in Fig. 35D is carried out. In this switch valve control, as shown in Fig. 35D, first of all, at step 733, it is determined whether or not the SOx processing flag has been set. When the SOx processing flag has not been set, the processing routine goes to step 734, at which it is determined whether or not the SOx amount Ws is larger than the set value Wk (MIN < Wk < Wso). When Ws ≤ Wk, the processing routine goes to step 736, at which the switch valve 27 is made the bypass closed position. When Ws ≤ Wk, even if the SOx is released from the SOx absorbent 18, the amount of the released SO_x is small, and therefore the switch valve 27 is made the bypass closed position.

Contrary to this, when Ws > Wk, the processing routine goes to step 735, at which it is determined whether or not the temperature T of exhaust gas flowing into the SO_x absorbent 18 is higher than the set value To (Fig. 26A). When T \leq To, the processing routine goes to step 736. Namely, when T \leq To, almost no SO_x is released from the SO_x

absorbent 18, and therefore the switch valve 27 is made the bypass closed position. Note that, the NO_x is released from the NO_x absorbent 19 when the switch valve 27 is held at the bypass closed position.

On the other hand, when it is decided at step 735 that T > To, the processing routine goes to step 737, at which the SO_x processing flag is set. When the SOx processing flag is set, the processing routine goes from step 733 to step 738, at which the switch valve 27 is switched to the bypass opening position. Namely, when Ws > Wk and T > To, a certain amount of the SOx is released from the SO_x absorbent 18, and therefore the switch valve 27 is made the bypass opening position so as to feed the released SO, into the bypass passage 24. Subsequently, at step 739, it is determined whether or not the amount Ws of SOx becomes smaller than the lower limit value MIN. When Ws becomes smaller than MIN, the processing routine goes to step 740, at which the SOx processing flag is reset. When the SO, processing flag is reset, in the next processing cycle, the processing routine goes from step 733 to step 734. since it is determined that Ws is equal to or smaller than Wk at this time, and therefore the processing routine goes to step 736, at which the switch valve 27 is switched to the bypass closed position.

On the other hand, where the SO_x flag has been set when the operation state is changed from the state where $K \ge 1.0$ to the state where K < 1.0, the processing routine goes from step 710 to step 711, at which the SO_x processing flag is reset. Subsequently, at step 712, the switch valve 27 is switched to the bypass closed position.

Figure 36 shows the calculation routine of the fuel injection time TAU, which routine is substantially the same as the routine shown in Fig. 34. Note that, this routine is repeatedly executed.

Namely, referring to Fig. 36, first of all, at step 750, the correction coefficient K determined in accordance with the engine operation state shown in Fig. 25 is calculated. Subsequently, at step 751, the basic fuel injection time TP is calculated from the map shown in Fig. 2. Subsequently, at step 752, it is determined whether or not the NOx releasing flag has been set, and when the NOx releasing flag has not been set, the processing routine goes to step 753, at which it is determined whether or not the SOx and NOx releasing flag has been set. When the SOx and NOx releasing flag has not been set, the processing routine goes to step 754, at which the correction coefficient K is made Kt, and then at step 755, the fuel injection time TAU (= TP · Kt) is calculated by multiplying the basic fuel injection time TP by Kt. Accordingly, when the NOx releasing flag and the SOx and NOx releasing flag have not been set, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes the air-fuel ratio determined by the correction coefficient K.

Contrary to this, when the NO_x releasing flag is set, the processing routine jumps to step 755, and when the SO_x and NO_x releasing flag is set, the processing routine goes to step 755. When the NO_x releasing flag is set, in the routine shown in Figs. 35A to 35D, Kt is made equal to KK1 (KK1 > 1.0), and therefore the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, while when the SO_x and NO_x releasing flag is set, in the routine shown in Figs. 35A to 35D, Kt is made equal to KK1 (KK1 > 1.0), and then Kt is made equal to KK2 (KK2 > 1.0), and therefore the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich.

Figures 37A to 37D show the flag switch valve control routine for executing the NO_x and SO_x releasing control shown in Fig. 30, which routine is executed by interruption at every predetermined time interval. Note that, in this embodiment, the flow chart part shown in Fig. 37A, Fig. 37B, and Fig. 37D is substantially the same as the flow chart part shown in Fig. 32A, Fig. 32B, and Fig. 32D, and the part which is basically different from them is only the flow chart part shown in Fig. 37C.

Namely, referring to Figs. 37A to 37D, first of all, at step 800, it is determined whether or not the correction coefficient Kt with respect to the basic fuel injection time TP is smaller than 1.0. When Kt < 1.0, that is, when the lean air-fuel mixture is fed into the combustion chamber 3, the processing routine goes to step 801, at which the NO_x amount Wn (= Wn + K₁ • N • PM) is calculated, and then the processing routine goes to step 802, at which the SO_x amount Ws (= Ws + K2 • N • PM) is calculated. Here, N indicates the engine rotational speed, P indicates the absolute pressure in the surge tank 10, and K₁ and K₂ indicate constants (K₁ > K₂). Then, the processing routine goes to step 809.

On the other hand, when it is determined at step 800 that $Kt \ge 1.0$, that is, when the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is the stoichiometric air-fuel ratio or rich, the processing routine goes to step 803, at which the NO_x amount $Wn (= Wn - Wn \cdot f(T) \cdot f(Kt))$ is calculated, and then the processing routine goes to step 804, at which the SO_x amount $Ws (= Ws - Ws \cdot g(T) \cdot g(Kt))$ is calculated. Here, f(T) and g(T) indicate the NO_x releasing rate and SO_x releasing rate shown in Fig. 26A, respectively, and f(Kt) and g(Kt) indicate the NO_x releasing rate and SO_x releasing rate shown in Fig. 26B, respectively

When the NO_x amount Wn is calculated at step 803, and the SO_x amount Ws is calculated at step 804, the processing routine goes to step 805, at

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which it is determined whether or not the NO_x amount Wn has become negative. When Wn < 0, the processing routine goes to step 806, at which Wn is made zero, and then, the processing routine goes to step 807. At step 807, it is determined whether or not the SO_x amount Ws becomes negative. When Ws < 0, the processing routine goes to step 808, at which Ws is made zero, and then the processing routine goes to step 809.

At step 809, it is determined whether or not the correction coefficient K determined according to the engine operation state shown in Fig. 25 is smaller than 1.0. When K < 1.0, that is, when the target air-fuel ratio determined according to the operation state of the engine is lean, the processing routine goes to step 810, at which it is determined whether or not the SO_x processing has been set. When the SOx processing flag has not been set, the routine jumps to step 813, at which it is determined whether or not the SOx and NOx releasing flag has been set. When the SOx and NOx releasing flag has not been set, the processing routine goes to step 814, at which it is determined whether or not the NO_x releasing flag has been set. When the NOx releasing flag has not been set, the processing routine goes to step 815.

At step 815, it is determined whether or not the SO_x amount Ws has become larger than the maximum allowable value Wso (Fig. 31). When Ws \leq Wso, the processing routine goes to step 816, at which it is determined whether or not the NO_x amount Wn has become larger than the maximum allowable value Wno. When Wn \leq Wno, the processing cycle is completed. At this time, the lean air-fuel mixture is fed into the combustion chamber 3, and the switch valve 27 is held at the bypass closed position.

On the other hand, when it is determined at step 816 that the Wn becomes larger than Wno, the processing routine goes to step 817, at which the NOx releasing flag is set, and then the processing cycle is completed. In the next processing cycle, it is determined at step 814 that the NO_x releasing flag has been set, and therefore the processing routine goes to step 818, at which the correction coefficient Kt is made KK1. The value of this KK1 is a value of about 1.1 to 1.2 with which the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes about 12.0 to 13.5. When Kt is made KK1, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich. Subsequently, at step 819, it is determined whether or not the NOx amount Wn has become smaller than the lower limit value MIN (Fig. 31), and when Wn ≥ MIN, the processing cycle is completed. Contrary to this, when Wn becomes smaller than MIN, the processing routine goes to step 820, at which the NOx releasing flag is set.

When the NO_x releasing flag is reset, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from rich to lean. Accordingly, during a period from when Wn becomes larger than Wno to when Wn becomes smaller than MIN, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, and during this time, the NO_x is released from the NO_x absorbent 19.

On the other hand, when it is decided at step 815 that the SO_x amount Ws has become larger than the maximum allowable value Wso, the processing routine goes to step 821, at which it is determined whether or not the temperature T of exhaust gas flowing into the SO_x absorbent 18 is higher than the set value To (Fig. 26A). When T \leq To, the processing cycle is completed. Contrary to this, when T > To, the processing routine goes to step 822, at which the SO_x and NO_x releasing flag is set and then the processing cycle is completed.

In the next processing cycle, it is decided at step 813 that the SO_x and NO_x releasing flag has been set, and therefore the processing routine goes to step 823, at which it is determined whether or not the SOx amount Ws has become smaller than the lower limit value MIN. When Ws > MIN, the processing routine goes to step 824, at which the correction coefficient Kt is made KK2. The value of this KK2 is a value of about 1.1 to 1.2 with which the air-fuel ratio of the air-fuel mixture fed into the engine combustion chamber 3 becomes about 12.0 to 13.5. It is also possible to make the value of this KK2 different from the value of KK1, or make this the same value as the value of KK1. When the correction coefficient Kt is made KK2. the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich. Subsequently, at step 825, the switch valve 27 is switched to the bypass opening position. Subsequently, the processing cycle is completed. Accordingly, if T > To when Ws becomes larger than Wso, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich from when Ws becomes larger than Wso to when Ws becomes smaller than MIN and, at the same time, the switch valve 27 is held at the bypass closed position. Thus, during this term, the SOx is released from the SOx absorbent 18, and the released SOx is fed into the bypass passage 24.

On the other hand, when it is determined at step 823 that Ws becomes smaller than MIN, the processing routine goes to step 826, at which the correction coefficient Kt is made KK1, and then the processing routine goes to step 827, at which the switch valve 27 is switched to the bypass closed position. Subsequently, at step 828, it is determined whether or not the NO_x amount Wn becomes smaller than the lower limit value MIN, and

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when Wn ≥ MIN, the processing cycle is completed. Contrary to this, when Wn becomes smaller than MIN, the processing routine goes to step 829, at which the SO_x and NO_x releasing flag is reset, and then the processing cycle is completed. Accordingly, when Ws becomes smaller than MIN, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich (Kt = KK1) until when Wn becomes smaller than MIN, and the switch valve 27 is held at the bypass closed position. Accordingly, this means that NO_x is released from the NO_x absorbent 19 during this time.

On the other hand, when it is determined at step 809 that K ≥ 1.0, that is, when the target airfuel ratio of the air-fuel mixture which should be fed into the combustion chamber 3 becomes the stoichiometric air-fuel ratio or rich, the processing routine goes to step 830, at which the NOx releasing flag is reset, and then the processing routine goes to step 831, at which the SOx and NOx releasing flag is reset. Subsequently, at step 832, the switch valve control shown in Fig. 37D is carried out. In this switch valve control, as shown in Fig. 37D, first of all, at step 833, it is determined whether or not the SOx processing flag has been set. When the SO_x processing flag has not been set, the processing routine goes to step 834, at which it is determined whether or not the SOx amount Ws is larger than the set up value Wk (MIN < Wk < Wso). When Ws ≤ Wk, the processing routine goes to step 836, at which the switch valve 27 is made the bypass closed position. When Ws ≤ Wk, even if the SO_x is released from the SO_x absorbent 18, the amount of the released SOx is small, and therefore the switch valve 27 is made the bypass closed position.

Contrary to this, when Ws > Wk, the processing routine goes to step 835, at which it is determined whether or not the temperature T of exhaust gas flowing into the SO_x absorbent 18 is higher than the set value To (Fig. 26A). When T \leq To, the processing routine goes to step 836. Namely, when T \leq To, almost no SO_x is released from the SO_x absorbent 18, and therefore switch valve 27 is made the bypass closed position. Note that, the NO_x is released from the NO_x absorbent 19 when the switch valve 27 is held at the bypass closed position.

On the other hand, when it is decided at step 835 that T > To, the processing routine goes to step 837, at which the SO_x processing flag is set. When the SO_x processing flag is set, the processing routine goes from step 833 to step 838, at which the switch valve 27 is switched to the bypass opening position. Namely, when Ws > Wk and T > To, a certain amount of the SO_x is released from the SO_x absorbent 18, and therefore the switch valve 27 is made the bypass opening position so

as to feed the released SO_x into the bypass passage 24. Subsequently, at step 839, it is determined whether or not the amount Ws of SO_x becomes smaller than the lower limit value MIN. When Ws becomes smaller than MIN, the processing routine goes to step 840, at which the SO_x processing flag is reset. When the SO_x processing flag is reset, in the next processing cycle, the processing routine goes from step 833 to step 834, since it is determined that Ws is equal to or smaller than Wk at this time, and therefore the processing routine goes to step 836, at which the switch valve 27 is switched to the bypass closed position.

On the other hand, where the SO_x flag has been set when the operation state is changed from the state where $K \ge 1.0$ to the state where K < 1.0, the processing routine goes from step 810 to step 811, at which the SO_x processing flag is reset. Subsequently, at step 812, the switch valve 27 is switched to the bypass closed position.

Figure 38 shows the calculation routine of the fuel injection time TAU, which routine is exactly the same as the routine shown in Fig. 36.

Namely, referring to Fig. 38, first of all, at step 850, the correction coefficient K determined in accordance with the engine operation state shown in Fig. 25 is calculated. Subsequently, at step 851, the basic fuel injection time TP is calculated from the map shown in Fig. 2. Subsequently, at step 852, it is determined whether or not the NOx releasing flag has been set, and when the NOx releasing flag has not been set, the processing routine goes to step 853, at which it is determined whether or not the SOx and NOx releasing flag has been set. When the SO_x and NO_x releasing flag has not been set, the processing routine goes to step 854, at which the correction coefficient K is made Kt, and then at step 855, the fuel injection time TAU (= TP · Kt) is calculated by multiplying the basic fuel injection time TP by Kt. Accordingly, when the NOx releasing flag and the SOx and NOx releasing flag have not been set, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes the air-fuel ratio determined by the correction coefficient K.

Contrary to this, when the NO_x releasing flag is set, the processing routine jumps to step 855, and when the SO_x and NO_x releasing flag is set, the processing routine goes to step 855. When the NO_x releasing flag is set, in the routine shown in Figs. 37A to 37D, Kt is made equal to KK1 (KK1 > 1.0), and therefore the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, while when the SO_x and NO_x releasing flag is set, in the routine shown in Figs. 37A to 37D, Kt is made equal to KK2 (KK2 > 1.0), and then Kt is made equal to KK1 (KK1 > 1.0), and therefore the air-fuel ratio of the air-fuel mixture fed

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into the combustion chamber 3 is made rich.

Figures 39A to 39E show the flag switch valve control routine for performing the NO_x and SO_x releasing control shown in Fig. 29 when the exhaust gas temperature T is lower than the set up temperature Tt, while performing the NO_x and SO_x releasing control shown in Fig. 30 when the exhaust gas temperature T becomes higher than the set temperature Tt, which routine is executed by interruption at every predetermined time interval. Note that, in this embodiment, the flow chart part shown in Fig. 39A, Fig. 39B, and Fig. 39E is substantially the same as the flow chart part shown in Fig. 32A, Fig. 32B, and Fig. 32D, and the part which is basically different from them is only a flow chart part shown in Fig. 39C and Fig. 39D.

Namely, referring to Figs. 39A to 39E, first of all, at step 900, it is determined whether or not the correction coefficient Kt with respect to the basic fuel injection time TP is smaller than 1.0. When Kt < 1.0, that is, when the lean air-fuel mixture is fed into the combustion chamber 3, the processing routine goes to step 901, at which the NO_x amount Wn (= Wn + K₁ \cdot N \cdot PM) is calculated, and then the processing routine goes to step 902, at which the SO_x amount Ws (= Ws + K2 \cdot N \cdot PM) is calculated. Here, N indicates the engine rotational speed, P indicates the absolute pressure in the surge tank 10, and K₁ and K₂ indicate constants (K₁ > K₂). Then, the processing routine goes to step 909.

On the other hand, when it is determined at step 900 that Kt \geq 1.0, that is, when the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is the stoichiometric air-fuel ratio or rich, the processing routine goes to step 903, at which the NO_x amount Wn (= Wn - Wn • f(T) • f-(Kt)) is calculated, and then the processing routine goes to step 904, at which the SO_x amount Ws (= Ws - Ws • g(T) • g (Kt)) is calculated. Here, f(T) and g(T) indicate the NO_x releasing rate and SO_x releasing rate shown in Fig. 26A, respectively, and f(Kt) and g(Kt) indicate the NO_x releasing rate and SO_x releasing rate shown in Fig. 26B, respectively

When the NO_x amount Wn is calculated at step 903, and the SO_x amount Ws is calculated at step 904, the processing routine goes to step 905, at which it is determined whether or not the NO_x amount Wn has become negative. When Wn < 0, the processing routine goes to step 906, at which Wn is made zero, and then, the processing routine goes to step 907. At step 907, it is determined whether or not the SO_x amount Ws becomes negative. When Ws < 0, the processing routine goes to step 908, at which Ws is made zero, and then the processing routine goes to step 909.

At step 909, it is determined whether or not the correction coefficient K determined according to

the engine operation state shown in Fig. 25 is smaller than 1.0. When K < 1.0, that is, when the target air-fuel ratio determined according to the operation state of the engine is lean, the processing routine goes to step 910, at which it is determined whether or not the SO_x processing has been set. When the SO_x processing flag has not been set, the routine jumps to step 913, at which it is determined whether or not the SO_x and NO_x releasing flag has been set. When the SO_x and NO_x releasing flag has not been set, the processing routine goes to step 914, at which it is determined whether or not the NO_x releasing flag has been set. When the NO_x releasing flag has not been set, the processing routine goes to step 915.

At step 915, it is determined whether or not the SO_x amount Ws has become larger than the maximum allowable value Wso (Fig. 31). When Ws \leq Wso, the processing routine goes to step 916, at which it is determined whether or not the NO_x amount Wn has become larger than the maximum allowable value Wno. When Wn \leq Wno, the processing cycle is completed. At this time, the lean air-fuel mixture is fed into the combustion chamber 3, and the switch valve 27 is held at the bypass closed position.

On the other hand, when it is determined at step 916 that the Wn becomes larger than Wno. the processing routine goes to step 917, at which the NO_x releasing flag is set, and then the processing cycle is completed. In the next processing cycle, it is determined at step 914 that the NO_x releasing flag has been set, and therefore the processing routine goes to step 918, at which the correction coefficient Kt is made KK1. The value of this KK1 is a value of about 1.1 to 1.2 with which the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes about 12.0 to 13.5. When Kt is made KK1, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich. Subsequently, at step 919, it is determined whether or not the NOx amount Wn has become smaller than the lower limit value MIN (Fig. 31), and when Wn ≥ MIN, the processing cycle is completed. Contrary to this, when Wn becomes smaller than MIN, the processing routine goes to step 920, at which the NOx releasing flag is set. When the NOx releasing flag is reset, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from rich to lean. Accordingly, during a period from when Wn becomes larger than Wno to when Wn becomes smaller than MIN, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, and during this time, the NOx is released from the NOx absorbent 19.

On the other hand, when it is decided at step 915 that the SO_x amount Ws has become larger

than the maximum allowable value Wso, the processing routine goes to step 921, at which it is determined whether or not the temperature T of exhaust gas flowing into the SO_x absorbent 18 is higher than the set value To (Fig. 26A). When T \leq To, the processing cycle is completed. Contrary to this, when T > To, the processing routine goes to step 922, at which the SO_x and NO_x releasing flag is set and then the processing cycle is completed.

In the next processing cycle, it is decided at step 913 that the SOx and NOx releasing flag has been set, and therefore the processing routine goes to step 923, at which it is determined whether or not the exhaust gas temperature T is higher than the set up temperature Tt (Tt > To). When T ≤ Tt, the processing routine goes to step 924, at which it is determined whether or not the NOx amount Wn becomes smaller than the lower limit value MIN. When Wn > MIN, the processing routine goes to step 925, at which the correction coefficient Kt is made KK1, and then the processing cycle is completed. Accordingly, when To < T ≤ Tt, if Ws becomes larger than Wso, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich (Kt = KK1) until Wn becomes smaller than MIN, and the switch valve 27 is held the bypass closed position. Accordingly, during this time, the NOx will be released from the NOx absorbent 19.

On the other hand, when it is decided at step 924 that Wn becomes smaller than MIN, the processing routine goes to step 926, at which the correction coefficient Kt is made KK2. The value of this KK2 is a value of about 1.1 to 1.2 with which the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes about 12.0 to 13.5. It is also possible to make the value of this KK2 different from the value of KK1, or make this the same value as the value of KK1. When the correction coefficient Kt is made KK2, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich. Subsequently, at step 927, the switch valve 27 is switched to the bypass opening position. Thus, the exhaust gas flowing out of the SO_x absorbent 18 is fed into the bypass passage 24.

Subsequently, at step 928, it is determined whether or not the SO_x amount Ws becomes smaller than the lower limit value MIN, and when Ws \geq MIN, the processing cycle is completed. Contrary to this, when Ws becomes smaller than MIN, the processing routine goes to step 929, at which the switch valve 27 is switched to the bypass closed position, and then the processing routine goes to step 930, at which the SO_x and NO_x releasing flag is reset. When the SO_x and NO_x releasing flag is reset, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is switched from

rich to lean. Accordingly, if $Tt \ge T > To$ when Ws becomes larger than Wno, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich (K = KK2) from when Wn becomes smaller than MIN to when Ws becomes smaller than MIN and, at the same time, the switch valve 27 is made the bypass opening position. Thus, during this time, the SO_x is released from the SO_x absorbent 18, and the released SO_x is fed into the bypass passage 24.

On the other hand, when it is determined at step 923 that T > Tt, the processing routine goes to step 931, at which it is determined whether or not the SO_x amount Ws has become smaller than the lower limit value MIN. When Ws > MIN, the processing routine goes to step 932, at which the correction coefficient Kt is made KK2. When the correction coefficient Kt is made KK2, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich. Subsequently, at step 933, the switch valve 27 is switched to the bypass opening position. Subsequently, the processing cycle is completed. Accordingly, if T > Tt when Ws becomes larger than Wso, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich from when Ws becomes larger than Wso to when Ws becomes smaller than MIN and. at the same time, the switch valve 27 is held at the bypass closed position. Thus, during this term, the SOx is released from the SOx absorbent 18, and the released SO_x is fed into the bypass passage

On the other hand, when it is determined at step 931 that Ws becomes smaller than MIN, the processing routine goes to step 934, at which the correction coefficient Kt is made KK1, and then the processing routine goes to step 935, at which the switch valve 27 is switched to the bypass closed position. Subsequently, at step 936, it is determined whether or not the NOx amount Wn becomes smaller than the lower limit value MIN, and when Wn ≥ MIN, the processing cycle is completed. Contrary to this, when Wn becomes smaller than MIN, the processing routine goes to step 937, at which the SO_x and NO_x releasing flag is reset, and then the processing cycle is completed. Accordingly, when Ws becomes smaller than MIN, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich (Kt = KK1) until when Wn becomes smaller than MIN, and the switch valve 27 is held at the bypass closed position. Accordingly, this means that NOx is released from the NO_x absorbent 19 during this time.

On the other hand, when it is determined at step 909 that $K \ge 1.0$, that is, when the target airfuel ratio of the air-fuel mixture which should be fed into the combustion chamber 3 becomes the stoichiometric air-fuel ratio or rich, the processing

routine goes to step 938, at which the NO_x releasing flag is reset, and then the processing routine goes to step 939, at which the SOx and NOx releasing flag is reset. Subsequently, at step 940, the switch valve control shown in Fig. 39E is carried out. In this switch valve control, as shown in Fig. 39E, first of all, at step 941, it is determined whether or not the SOx processing flag has been set. When the SOx processing flag has not been set, the processing routine goes to step 942, at which it is determined whether or not the SO_x amount Ws is larger than the set value Wk (MIN < Wk < Wso). When Ws ≦ Wk, the processing routine goes to step 944, at which the switch valve 27 is made the bypass closed position. When Ws ≦ Wk, even if the SOx is released from the SOx absorbent 18, the amount of the released SOx is small, and therefore the switch valve 27 is made the bypass closed position.

Contrary to this, when Ws > Wk, the processing routine goes to step 943, at which it is determined whether or not the temperature T of exhaust gas flowing into the SO_x absorbent 18 is higher than the set value To (Fig. 26A). When T \leq To, the processing routine goes to step 944. Namely, when T \leq To, almost no SO_x is released from the SO_x absorbent 18, and therefore switch valve 27 is made the bypass closed position. Note that, the NO_x is released from the NO_x absorbent 19 when the switch valve 27 is held at the bypass closed position.

On the other hand, when it is decided at step 943 that T > To, the processing routine goes to step 945, at which the SO_x processing flag is set. When the SOx processing flag is set, the processing routine goes from step 941 to step 946, at which the switch valve 27 is switched to the bypass opening position. Namely, when Ws > Wk and T > To, a certain amount of the SO_x is released from the SOx absorbent 18, and therefore the switch valve 27 is made the bypass opening position so as to feed the released SOx into the bypass passage 24. Subsequently, at step 947, it is determined whether or not the amount Ws of SOx becomes smaller than the lower limit value MIN. When Ws becomes smaller than MIN, the processing routine goes to step 948, at which the SOx processing flag is reset. When the SOx processing flag is reset, in the next processing cycle, the processing routine goes from step 941 to step 942, since it is determined that Ws is equal to or smaller than Wk at this time, and therefore the processing routine goes to step 944, at which the switch valve 27 is switched to the bypass closed position.

On the other hand, where the SO_x flag has been set when the operation state is changed from the state where $K \ge 1.0$ to the state where K < 1.0, the processing routine goes from step 910 to step

911, at which the SO_x processing flag is reset. Subsequently, at step 912, the switch valve 27 is switched to the bypass closed position.

Figure 40 shows the calculation routine of the fuel injection time TAU, which routine is exactly the same as the routine shown in Fig. 36.

Namely, referring to Fig. 40, first of all, at step 950, the correction coefficient K determined in accordance with the engine operation state shown in Fig. 25 is calculated. Subsequently, at step 951, the basic fuel injection time TP is calculated from the map shown in Fig. 2. Subsequently, at step 952, it is determined whether or not the NO_x releasing flag has been set, and when the NOx releasing flag has not been set, the processing routine goes to step 953, at which it is determined whether or not the SO_x and NO_x releasing flag has been set. When the SO_x and NO_x releasing flag has not been set, the processing routine goes to step 954, at which the correction coefficient K is made Kt, and then at step 955, the fuel injection time TAU (= TP • Kt) is calculated by multiplying the basic fuel injection time TP by Kt. Accordingly, when the NO_x releasing flag and the SO_x and NO_x releasing flag have not been set, the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 becomes the air-fuel ratio determined by the correction coefficient K.

Contrary to this, when the NO_x releasing flag is set, the processing routine jumps to step 955, and when the SO_x and NO_x releasing flag is set, the processing routine goes to step 955. When the NO_x releasing flag is set, in the routine shown in Figs. 39A to 39E, Kt is made equal to KK1 (KK1 > 1.0), and therefore the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich, while when the SO_x and NO_x releasing flag is set, in the routine shown in Figs. 39A to 39E, Kt is made equal to KK1 (KK1 > 1.0) or Kt is made equal to KK2 (KK2 > 1.0), and therefore the air-fuel ratio of the air-fuel mixture fed into the combustion chamber 3 is made rich.

LIST OF REFERENCES

- 16 exhaust manifold
- 17 exhaust pipe
- 18 SO_x absorbent
- 19 NO_x absorbent
- 24 bypass passage
- 27 switch valve

Claims

- 1. An exhaust purification device of an internal combustion engine provided with:
 - an exhaust passage;
 - an NOx absorbent which is arranged in

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said exhaust passage, absorbs the NO_x when the air-fuel ratio of an inflowing exhaust gas is lean and, at the same time, releases the absorbed NO_x when an oxygen concentration in the inflowing exhaust gas is lowered;

an SO_x absorbent which is arranged in said exhaust passage on the upstream side of said NO_x absorbent, absorbs the SO_x when the air-fuel ratio of the inflowing exhaust gas is lean and, at the same time, releases the absorbed SO_x when the air-fuel ratio of the inflowing exhaust gas is made rich; and

an air-fuel ratio control means which controls the air-fuel ratio of the exhaust gas flowing into said SO_x absorbent, usually maintains the air-fuel ratio of the exhaust gas flowing into said SO_x absorbent lean, and makes the airfuel ratio of the exhaust gas flowing into said SO_x absorbent rich when the SO_x should be released from said SO_x absorbent.

- 2. An exhaust purification device of an internal combustion engine according to claim 1, wherein the NO_x absorbent contains at least one member selected from alkali metals consisting of potassium, sodium, lithium, and cesium, alkali earths consisting of barium and calcium, and rare earths consisting of lanthanum and yttrium and platinum.
- An exhaust purification device of an internal combustion engine according to claim 1, wherein the SO_x absorbent contains at least one member selected from copper, iron, manganese, nickel, sodium, tin, titanium, lithium, and titania.
- An exhaust purification device of an internal combustion engine according to claim 1, wherein the SO_x absorbent contains the platinum.
- 5. An exhaust purification device of an internal combustion engine according to claim 1, wherein all the exhaust gas discharged from the engine flows into the SO_x absorbent and the NO_x absorbent.
- An exhaust purification device of an internal combustion engine according to claim 5, wherein the SO_x absorbent and the NO_x absorbent are arranged in one casing.
- 7. An exhaust purification device of an internal combustion engine according to claim 1, wherein said air-fuel ratio control means controls the air-fuel ratio of the exhaust gas flowing into the SO_x absorbent by controlling the

air-fuel ratio of the air-fuel mixture burned in the engine; the SO_x contained in the exhaust gas is absorbed into the SO_x absorbent when the air-fuel ratio of the exhaust gas flowing into the SO_x absorbent is maintained lean by maintaining the air-fuel ratio of the air-fuel mixture burned in the engine lean, while the NO_x contained in the exhaust gas is absorbed into the NO_x absorbent.

- 8. An exhaust purification device of an internal combustion engine according to claim 7, wherein said air-fuel ratio control means releases the SO_x from the SO_x absorbent and, at the same time, makes the air-fuel ratio of the air-fuel mixture burned in the engine rich when the NO_x should be released from the NO_x absorbent.
- 9. An exhaust purification device of an internal combustion engine according to claim 8, wherein when said air-fuel ratio control means should release the SO_x from the SO_x absorbent and, at the same time, release the NO_x from the NO_x absorbent, it first makes the airfuel ratio of the exhaust gas flowing into the SO_x absorbent and the NO_x absorbent a first degree of richness determined in advance, and then maintains the same at a rich state by a second degree of richness smaller than this first degree of richness.
 - 10. An exhaust purification device of an internal combustion engine according to claim 9, wherein said air-fuel ratio control means controls said first degree of richness and second degree of richness in accordance with a temperature representative of the temperature of the SO_x absorbent.
- 11. An exhaust purification device of an internal combustion engine according to claim 10, wherein the temperature representing the temperature of the SO_x absorbent is the temperature of the exhaust gas flowing into the SO_x absorbent.
- 12. An exhaust purification device of an internal combustion engine according to claim 10, wherein said air-fuel ratio control means makes said first degree of richness larger as the temperature representing the temperature of the SO_x absorbent becomes higher.
- 13. An exhaust purification device of an internal combustion engine according to claim 12, wherein said air-fuel ratio control means makes the time for which the air-fuel ratio of the

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exhaust gas is maintained at said first degree of richness shorter as the temperature representing the temperature of the SO_x absorbent becomes higher.

- 14. An exhaust purification device of an internal combustion engine according to claim 10, wherein said air-fuel ratio control means makes said second degree of richness larger as the temperature representing the temperature of the SO_x absorbent becomes higher.
- 15. An exhaust purification device of an internal combustion engine according to claim 10, wherein said air-fuel ratio control means makes the time for which the air-fuel ratio of the exhaust gas is maintained at said second degree of richness shorter as the temperature representing the temperature of the SO_x absorbent becomes higher.
- 16. An exhaust purification device of an internal combustion engine according to claim 8, wherein said air-fuel ratio control means makes the air-fuel ratio of the air-fuel mixture rich so as to release the NO_x from the NO_x absorbent with a time interval shorter than the time interval at which it makes the air-fuel ratio of the air-fuel mixture rich so as to release the SO_x from the SO_x absorbent and release the NO_x from the NO_x absorbent.
- 17. An exhaust purification device of an internal combustion engine according to claim 16, wherein said air-fuel ratio control means first of all makes the air-fuel ratio of the exhaust gas flowing into the SO_x absorbent and the NO_x absorbent the predetermined degree of richness when the NO_x should be released from the NO_x absorbent, and then maintains the same at the stoichiometric air-fuel ratio.
- 18. An exhaust purification device of an internal combustion engine according to claim 17, wherein said air-fuel ratio control means controls said degree of richness in accordance with a temperature representative of the temperature of the NO_x absorbent.
- 19. An exhaust purification device of an internal combustion engine according to claim 18, wherein the temperature representing the temperature of the NO_x absorbent is the temperature of the exhaust gas flowing into the NO_x absorbent.
- An exhaust purification device of an internal combustion engine according to claim 18,

wherein said air-fuel ratio control means makes said degree of richness larger as the temperature representing the temperature of the NO_x absorbent becomes higher.

- 21. An exhaust purification device of an internal combustion engine according to claim 20, wherein said air-fuel ratio control means makes the time for which the air-fuel ratio of the exhaust gas is maintained at said degree of richness shorter as the temperature representing the temperature of the NO_x absorbent becomes higher.
- 22. An exhaust purification device of an internal combustion engine according to claim 17, wherein said air-fuel ratio control means makes the time for which the air-fuel ratio of the exhaust gas is maintained at the stoichiometric air-fuel ratio shorter as the temperature representing the temperature of the SO_x absorbent becomes higher.
 - 23. An exhaust purification device of an internal combustion engine according to claim 1, wherein: provision is made of a bypass passage which is branched from the exhaust passage positioned between the SOx absorbent and the NOx absorbent so as to bypass the NO_x absorbent, a switch valve arranged at the branch portion of the bypass passage from the exhaust passage, and a valve control means which performs the switching control of said switch valve so as to selectively introduce the exhaust gas to either of the NOx absorbent or the bypass passage; said valve control means holds the switch valve at a position at which the exhaust gas flows into the NO_x absorbent when the NOx should be released from the NO_x absorbent and switches the switch valve to a position at which the exhaust gas flowing into the bypass passage when the SOx should be released from the SOx absorbent; and said air-fuel ratio control means lowers the oxygen concentration in the exhaust gas flowing into the NO_x absorbent when the NO_x should be released from the NOx absorbent and makes the air-fuel ratio of the exhaust gas flowing into the SO_x absorbent rich when the SO_x should be released from the SO_x absorbent.
 - 24. An exhaust purification device of an internal combustion engine according to claim 23, wherein said valve control means and said airfuel ratio control means hold the switch valve at a position at which the exhaust gas flows into the NO_x absorbent when the SO_x should be released from the SO_x absorbent and, at

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the same time, make the air-fuel ratio of the exhaust gas flowing into the SO_x absorbent rich, and thereafter switches the switch valve to a position at which the exhaust gas flows into the bypass passage and, at the same time, continuously maintains the air-fuel ratio of the exhaust gas flowing into the SO_x absorbent rich.

- 25. An exhaust purification device of an internal combustion engine according to claim 23, wherein said valve control means and said airfuel ratio control means hold the switch valve at a position at which the exhaust gas flows into the bypass passage when the SO_x should be released from the SO_x absorbent and, at the same time, make the air-fuel ratio of the exhaust gas flowing into the SO_x absorbent rich, and thereafter switches the switch valve to the position at which the exhaust gas flows into the NO_x absorbent and, at the same time, continuously maintains the air-fuel ratio of the exhaust gas flowing into the SO_x absorbent rich.
- 26. An exhaust purification device of an internal combustion engine according to claim 23, wherein said valve control means and said airfuel ratio control means hold the switch valve at a position at which the exhaust gas flows into the NO_x absorbent if the temperature representing the temperature of the SOx absorbent is lower than the predetermined set up temperature when the SOx should be released from the SO_x and, at the same time, make the air-fuel ratio of the exhaust gas flowing into the SO_x absorbent rich, and thereafter switch the switch valve to a position at which the exhaust gas flows into the bypass passage and, at the same time, continuously maintain the air-fuel ratio of the exhaust gas flowing into the SOx absorbent rich; said valve control means and said air-fuel ratio control means switch the switch valve to a position at which the exhaust gas flows into the bypass passage if the temperature representing the temperature of the SO_x absorbent is higher than the predetermined set temperature when the SOx should be released from the SOx and, at the same time, make the air-fuel ratio of the exhaust gas flowing into the SOx absorbent rich, and thereafter hold the switch valve at a position at which the exhaust gas flows into the NOx absorbent and, at the same time, continuously maintain the air-fuel ratio of the exhaust gas flowing into the SO_x absorbent rich.

- 27. An exhaust purification device of an internal combustion engine according to claim 1, wherein provision is made of an NO_x releasing control means which lowers the oxygen concentration in the exhaust gas flowing into the NO_x absorbent exactly for a second set period determined in advance so as to release the NO_x from the NO_x absorbent when the period for which the air-fuel ratio of the exhaust gas flowing into the NO_x absorbent is made lean and the NO_x is absorbed into the NO_x absorbent exceeds the predetermined first set period.
- 28. An exhaust purification device of an internal combustion engine according to claim 28, wherein said NO_x releasing control means provides an NO_x amount estimation means which estimates the amount of NO_x absorbed in the NO_x absorbent; and said NO_x releasing control means decides that said first set period has elapsed when the NO_x amount estimated by said NO_x amount estimation means exceeds a predetermined maximum value.
- 29. An exhaust purification device of an internal combustion engine according to claim 28, wherein said NO_x amount estimation means decides that the amount of NO_x absorbed in the NO_x absorbent exceeds said maximum value when the cumulative value of the engine rotational speed exceeds a predetermined set value.
- 30. An exhaust purification device of an internal combustion engine according to claim 30, wherein said NO_x amount estimation means estimates the amount of NOx absorbed into the NO_x absorbent from the amount of NO_x contained in the exhaust gas when the air-fuel ratio of the exhaust gas flowing into the NOx absorbent is lean, estimates the amount of NO_x released from the NO_x absorbent based on the degree of richness of said exhaust gas when the air-fuel ratio of the exhaust gas flowing into the NOx absorbent is rich and based on the temperature representing the temperature of the NOx absorbent, and estimates the amount of NOx continuously absorbed into the NOx absorbent from this estimated NOx release.
- 31. An exhaust purification device of an internal combustion engine according to claim 30, wherein said NO_x releasing control means decides that said second set period has elapsed when the NO_x amount estimated by said NO_x estimation means becomes smaller than a pre-

determined minimum value.

- 32. An exhaust purification device of an internal combustion engine according to claim 1, wherein provision is made of an SO_x releasing control means which makes the air-fuel ratio of the exhaust gas flowing into the SO_x absorbent rich exactly for a second set period determined in advance so as to release the SO_x from the SO_x absorbent when the period for which the air-fuel ratio of the exhaust gas flowing into the SO_x absorbent is made lean and the SO_x is absorbed into the SO_x absorbent exceeds the predetermined first set period.
- 33. An exhaust purification device of an internal combustion engine according to claim 32, wherein said SO_x releasing control means provides an SO_x amount estimation means which estimates the amount of NO_x absorbed in the SO_x absorbent; and said SO_x releasing control means decides that said first set period has elapsed when the SO_x amount estimated by said SO_x amount estimation means exceeds a predetermined maximum value and decides that said second set period has elapsed when the SO_x amount estimated by said SO_x amount estimation means becomes smaller than a predetermined maximum value.
- 34. An exhaust purification device of an internal combustion engine according to claim 33, wherein said SO_x amount estimation means estimates the amount of SOx absorbed into the SO_x absorbent from the amount of SO_x contained in the exhaust gas when the air-fuel ratio of the exhaust gas flowing into the SOx absorbent is lean, estimates the amount of SOx released from the SOx absorbent based on the degree of richness of said exhaust gas when the air-fuel ratio of the exhaust gas flowing into the SO_x absorbent is rich and based on the temperature representing the temperature of the SOx absorbent, and estimates the amount of SO_{κ} continuously absorbed into the SO_{κ} absorbent from this released SOx amount.
- 35. An exhaust purification device of an internal combustion engine according to claim 1, wherein said air-fuel ratio control means controls the air-fuel ratio of the exhaust gas in the exhaust passage and makes the air-fuel ratio of the exhaust gas flowing into the SO_x absorbent rich when the SO_x should be released from the SO_x absorbent.
- An exhaust purification device of an internal combustion engine according to claim 35,

wherein said air-fuel ratio control means feeds a reduction agent into the exhaust passage when the SO_x should be released from the SO_x absorbent.

37. An exhaust purification device of an internal combustion engine according to claim 36, wherein the above-described reduction agent is composed of at least one member selected from gasoline, isooctane, hexane, heptane, butane, propane, light oil, and lamp oil.

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Fig.1

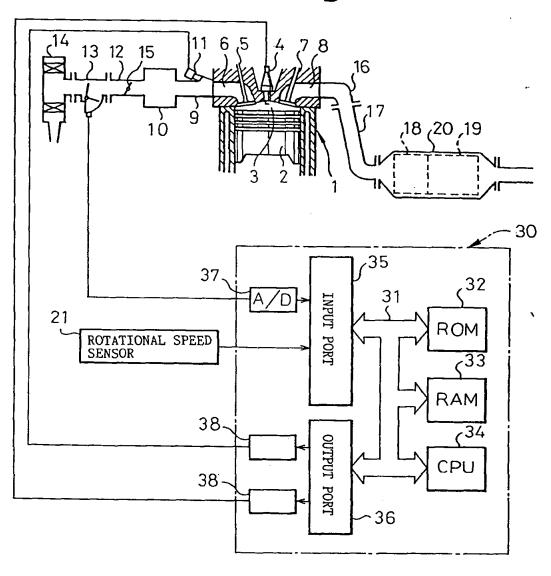


Fig. 2

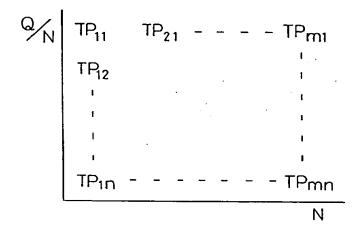


Fig.3

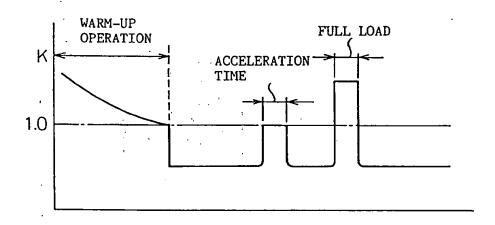


Fig. 4

CO

O2

RICH STOICHIOMETRIC LEAN
AIR-FUEL RATIO

NO_x
NO_x
NO₂

Fig. 5A

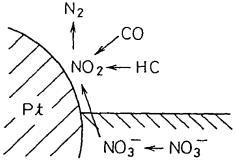


Fig.5B

Fig.6

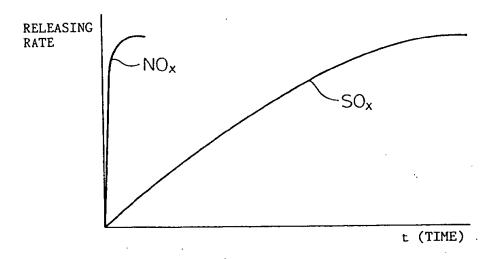


Fig.7

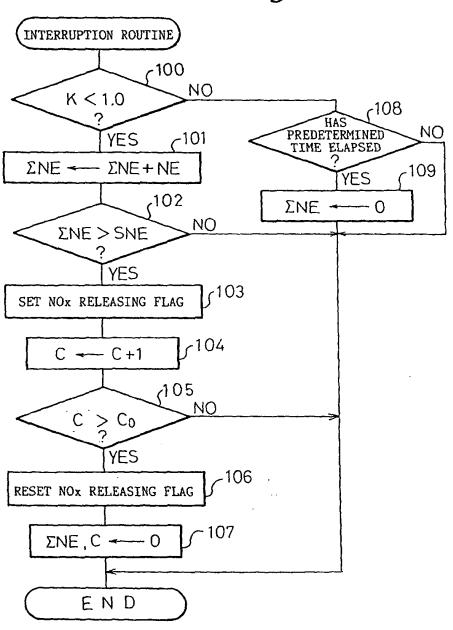


Fig. 8

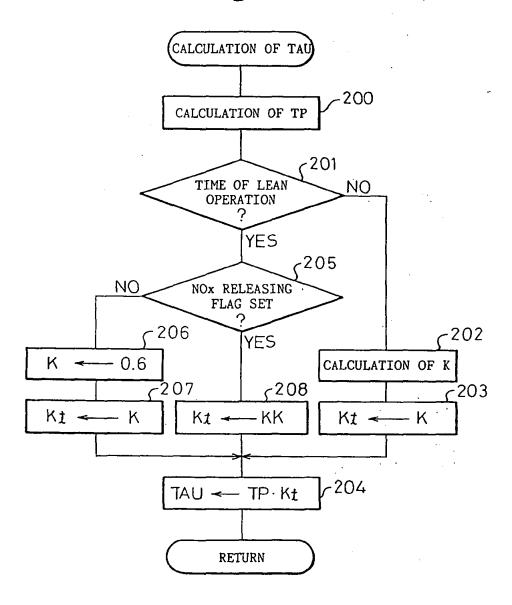


Fig.9

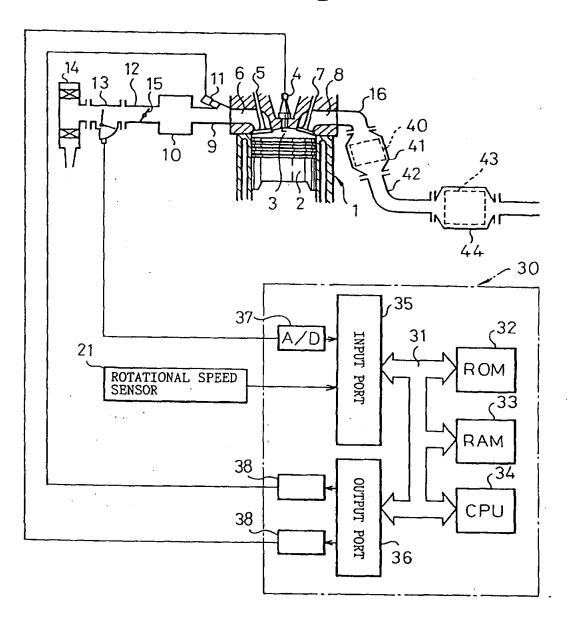


Fig.10

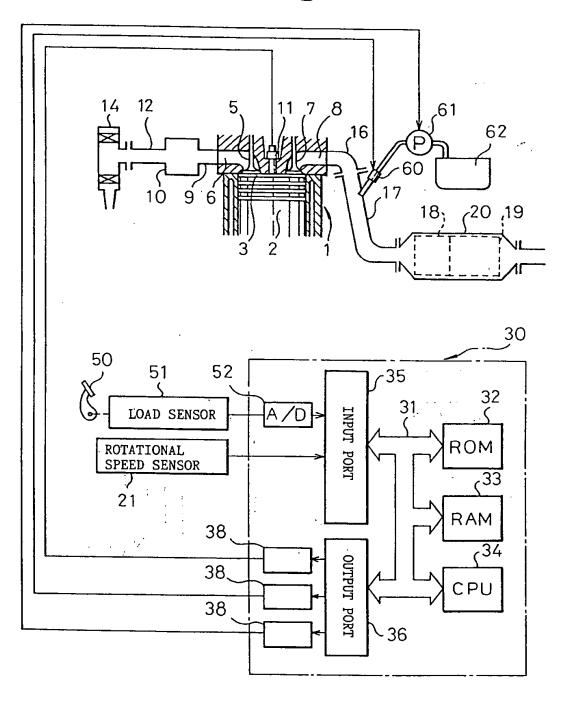


Fig.11

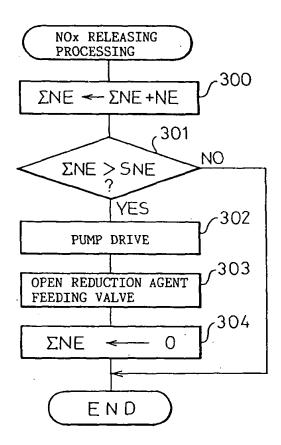


Fig.12

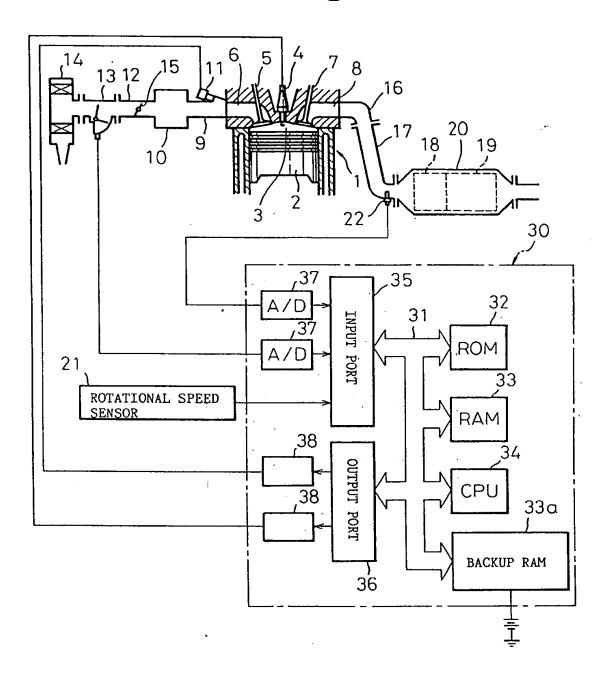


Fig.13

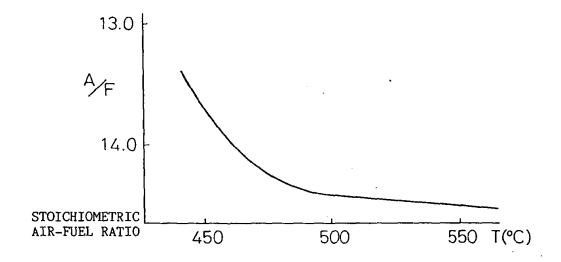


Fig.14

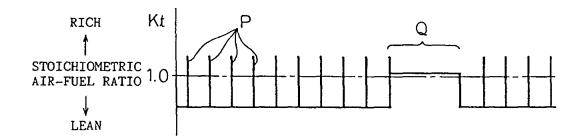
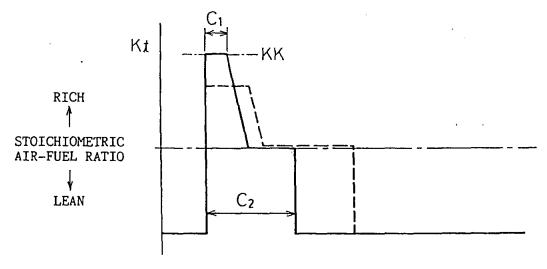


Fig.15



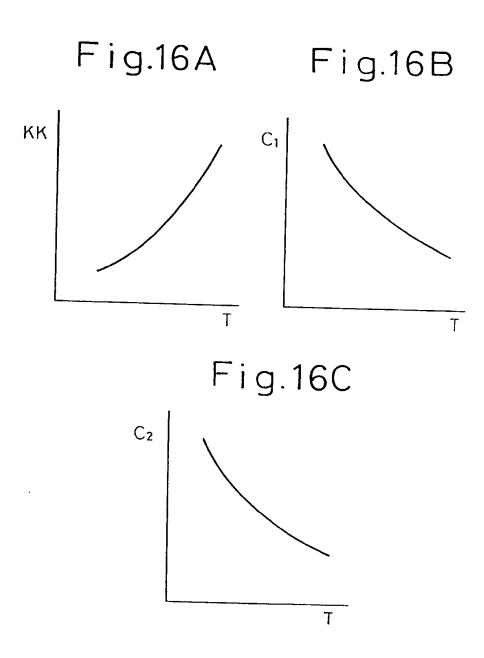
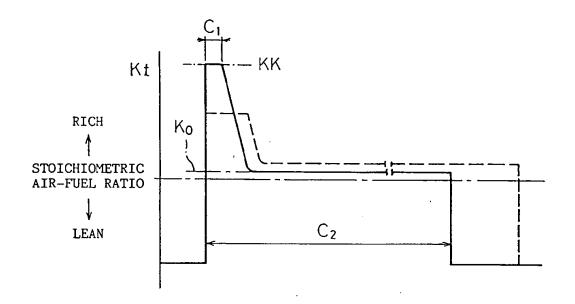


Fig. 17



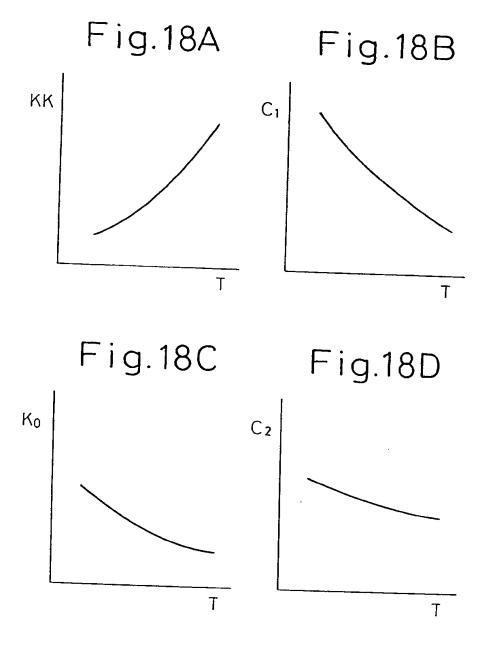


Fig.19

Q	T ₁₁	T ₂₁		_	 Tm1
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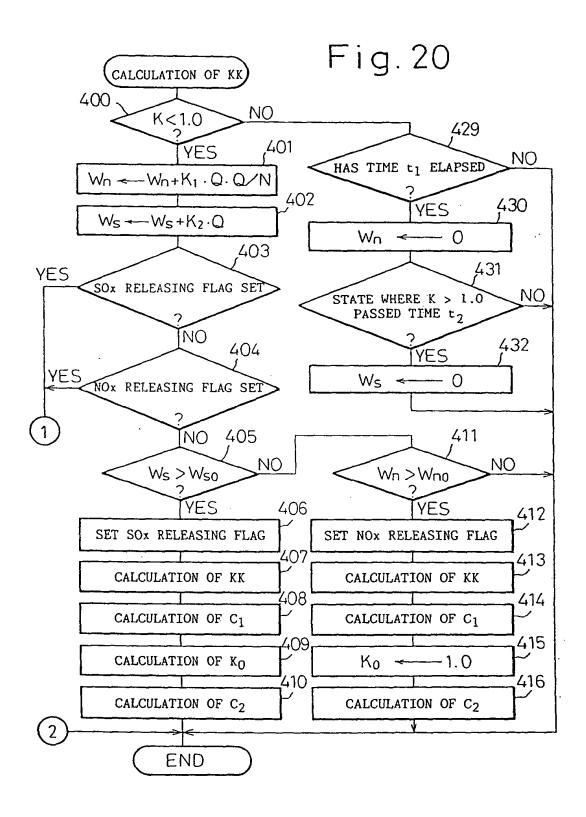


Fig.21

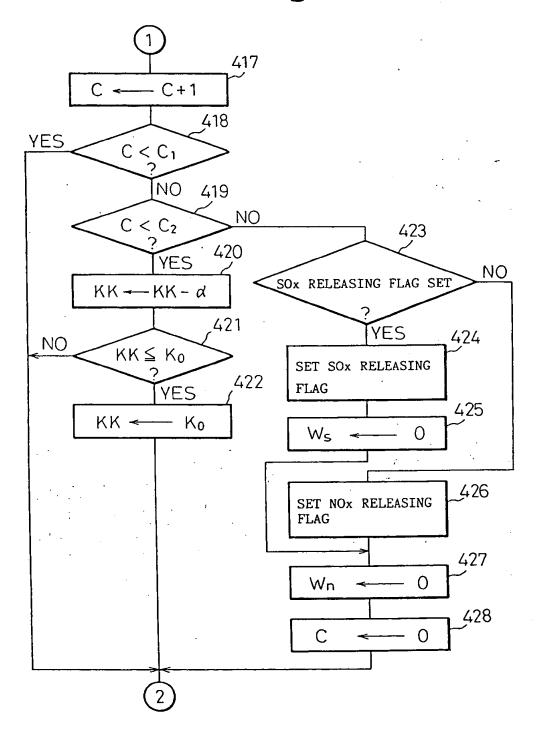


Fig. 22

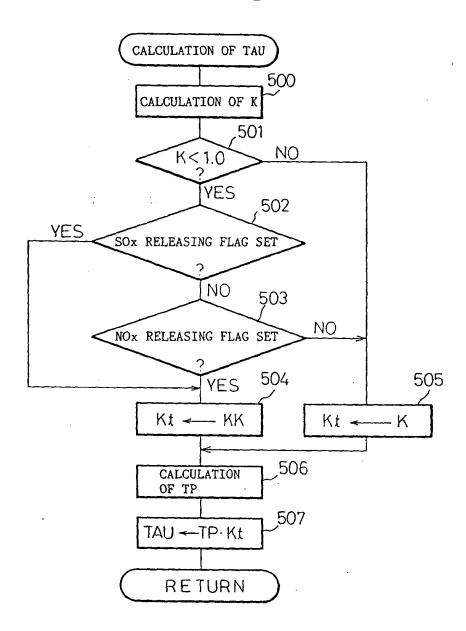


Fig. 23

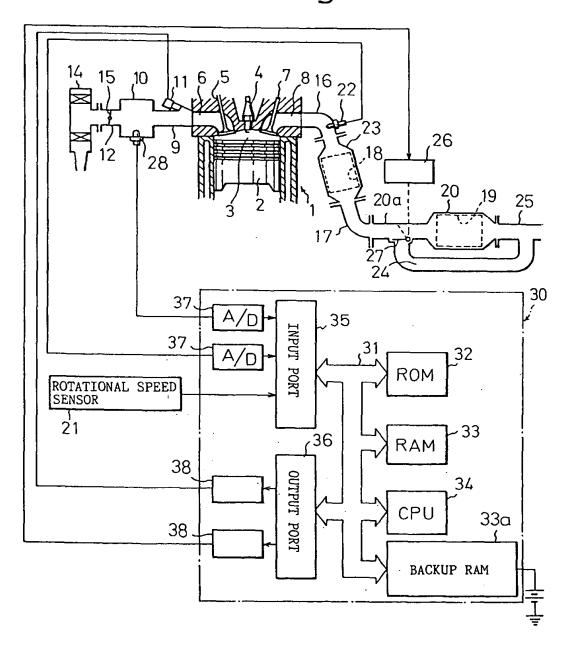


Fig. 24

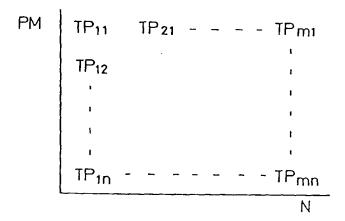


Fig. 25

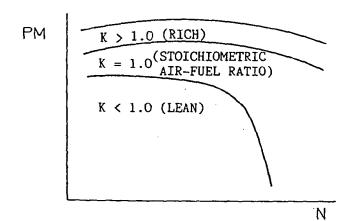


Fig.26A

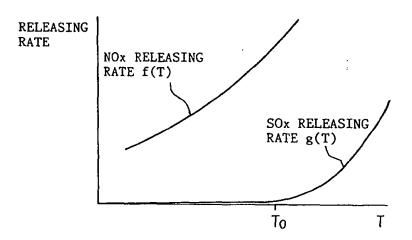
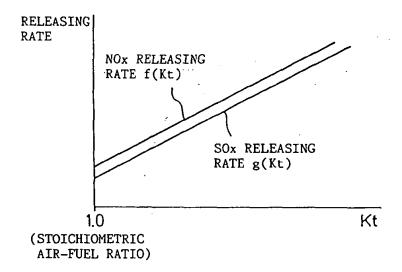


Fig.26B



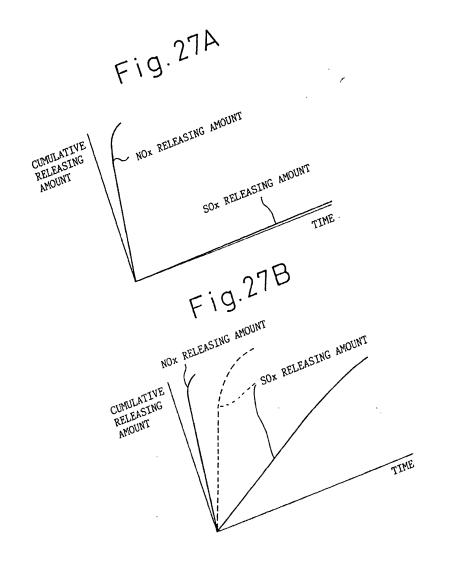


Fig. 28

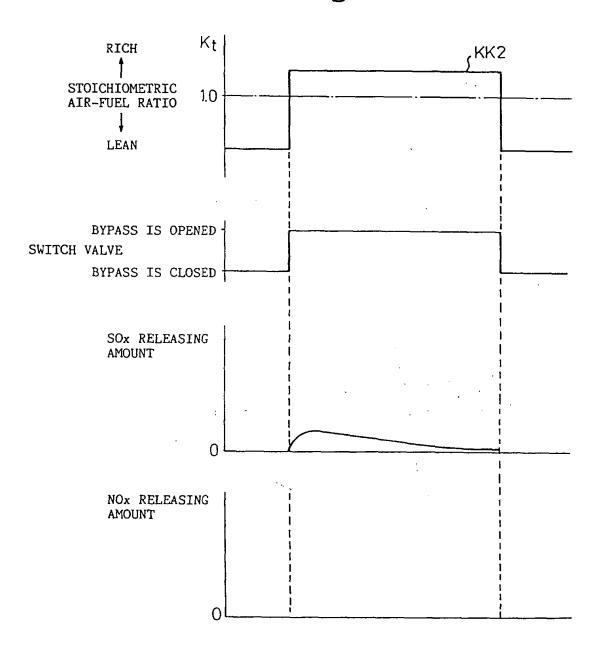
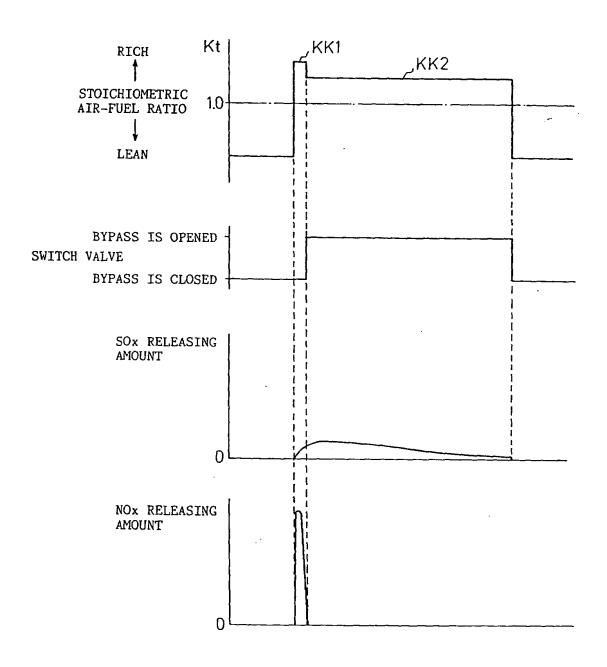
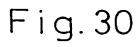


Fig. 29





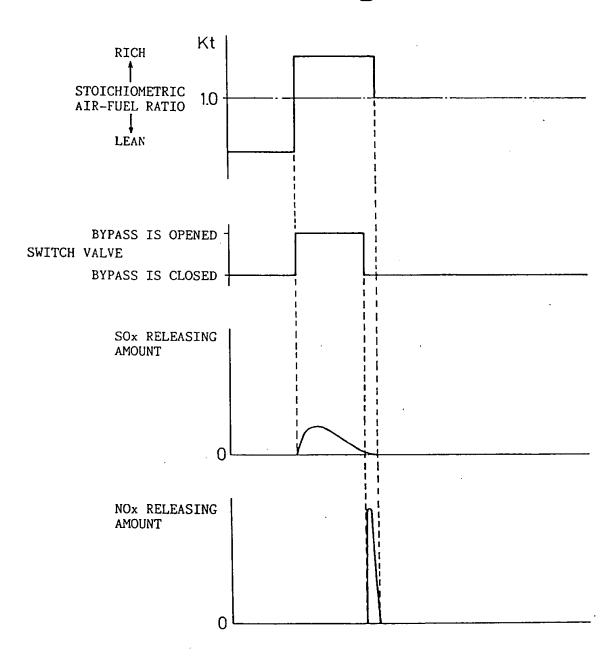


Fig. 31

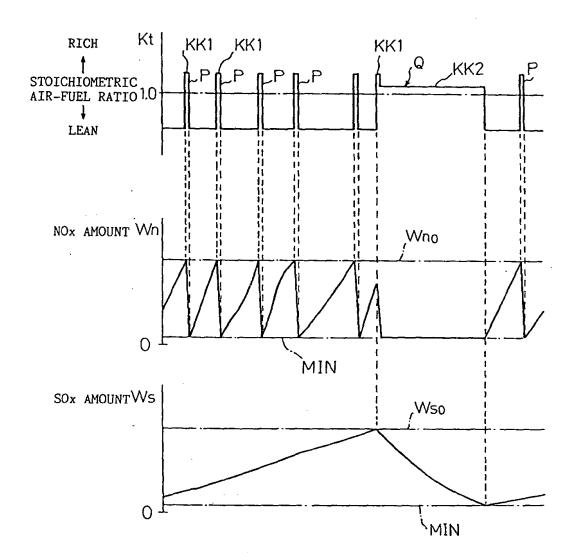
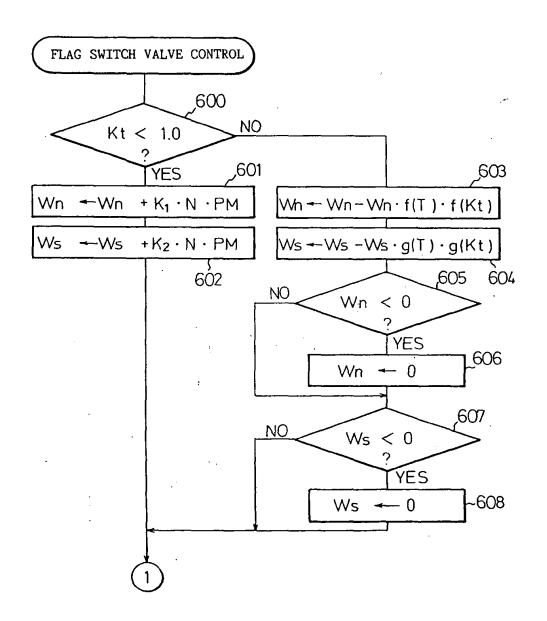


Fig. 32A



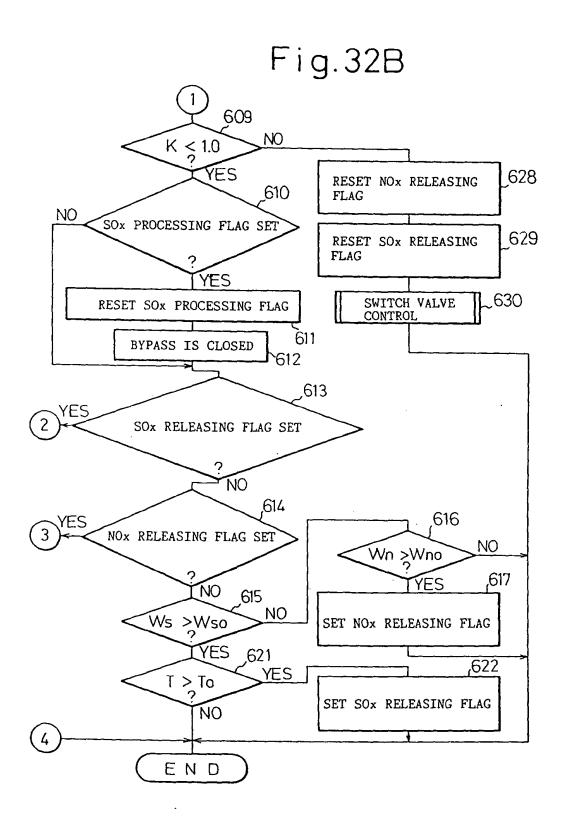


Fig.32C

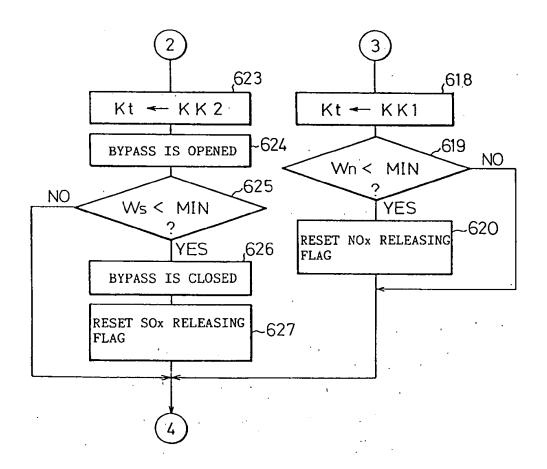


Fig.32D

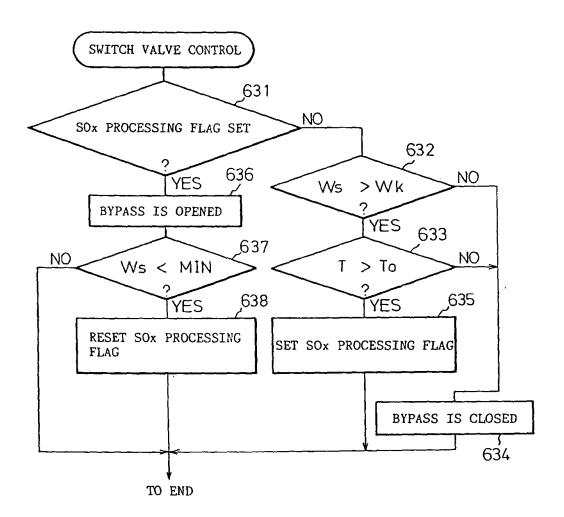


Fig.33

PM	T ₁₁	T ₂₁	_		_	_	_	T _{m1}	
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					-			N	

Fig. 34

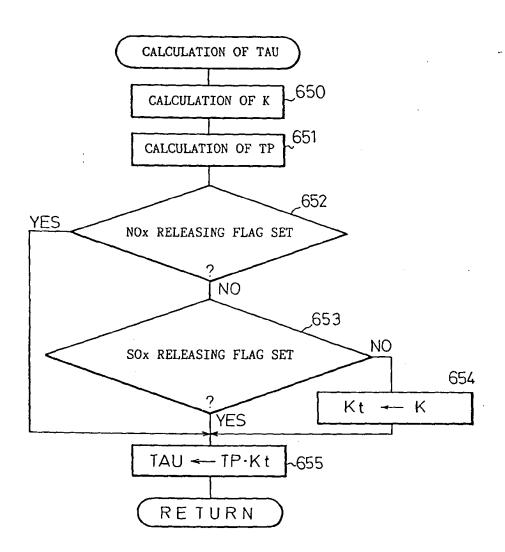


Fig.35A

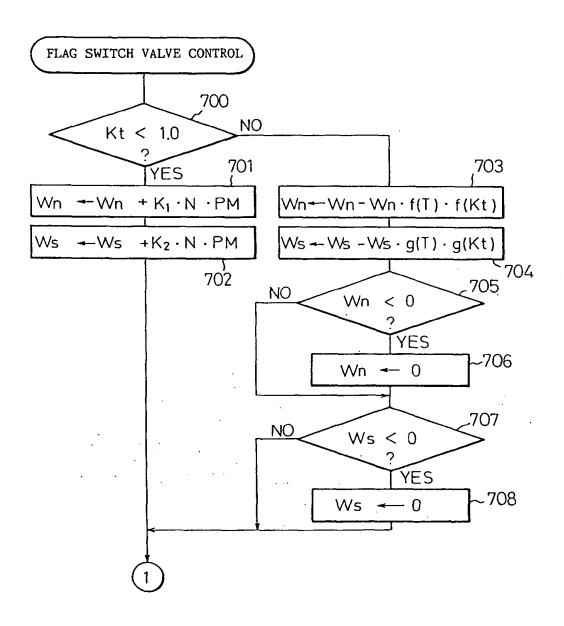


Fig.35B

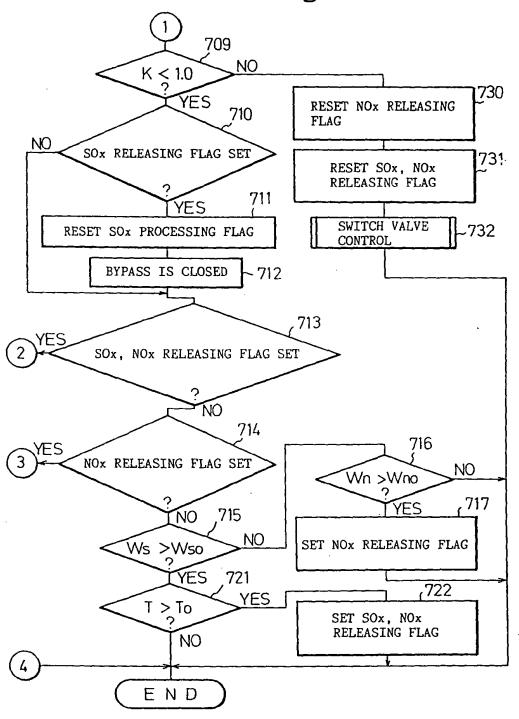


Fig.35C

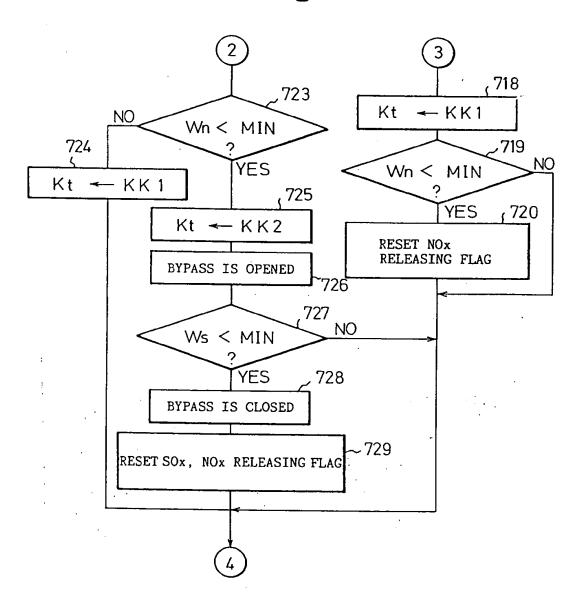


Fig. 35D

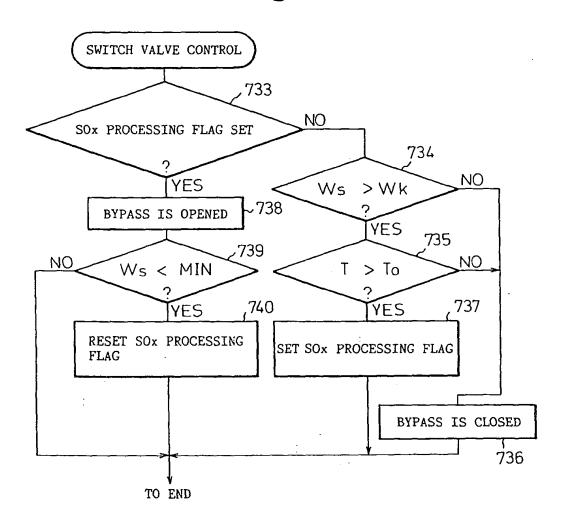


Fig.36

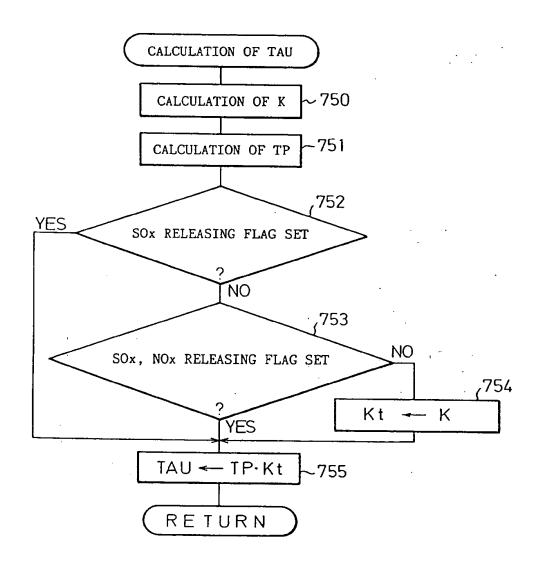
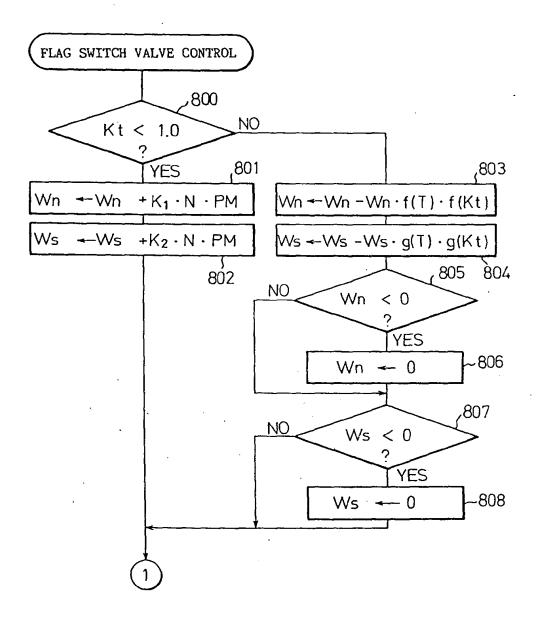


Fig. 37A



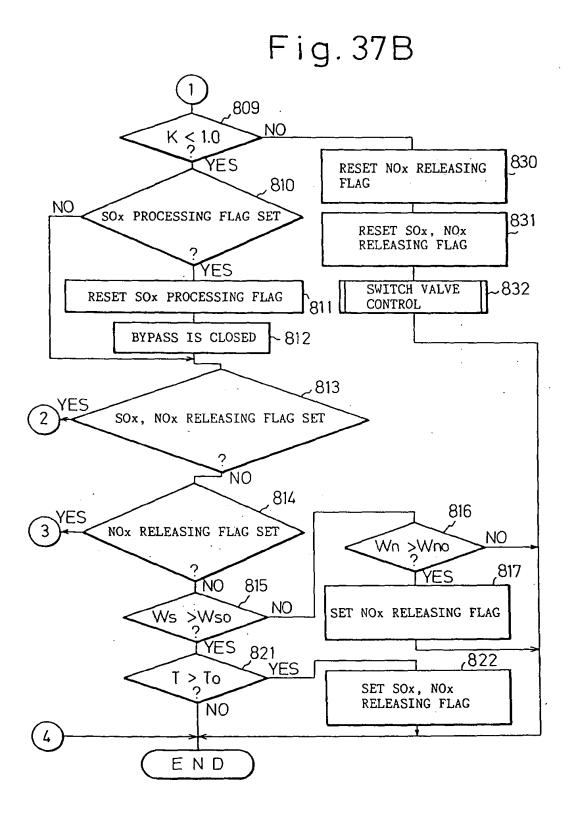


Fig.37C

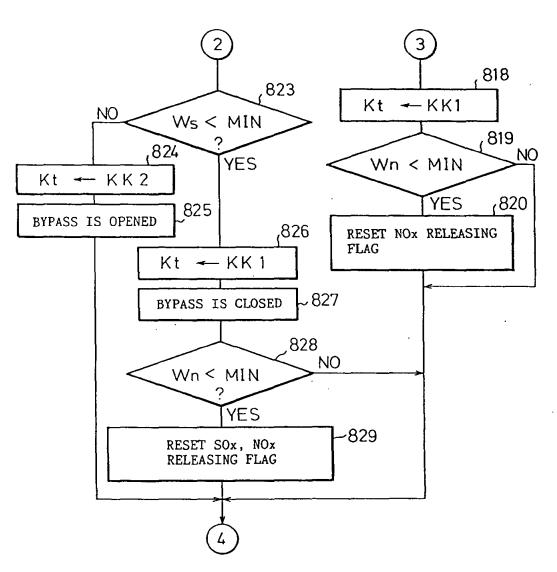


Fig.37D

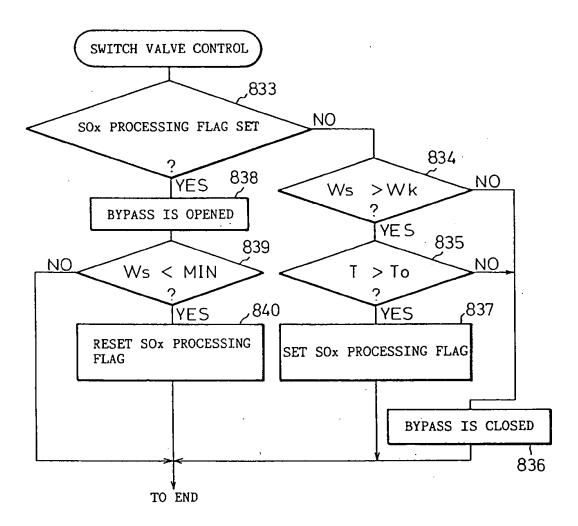


Fig.38

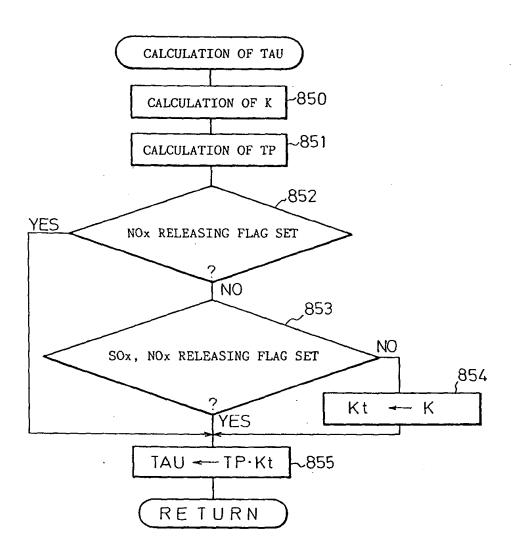
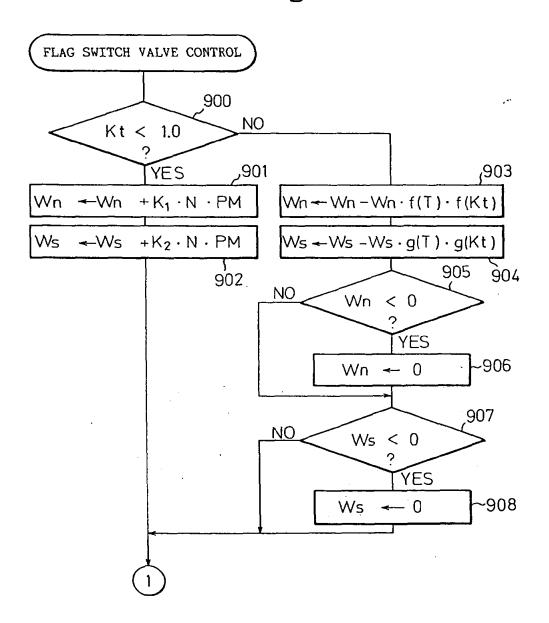


Fig.39A



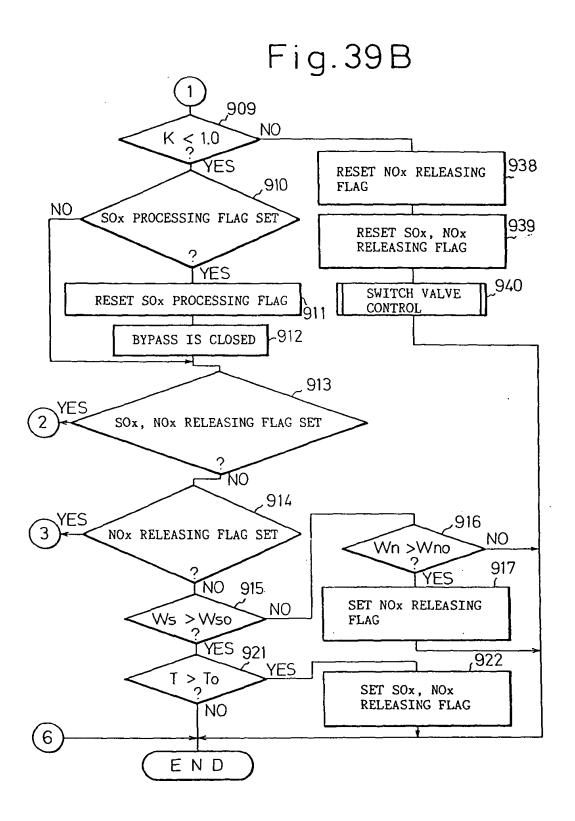


Fig.39C

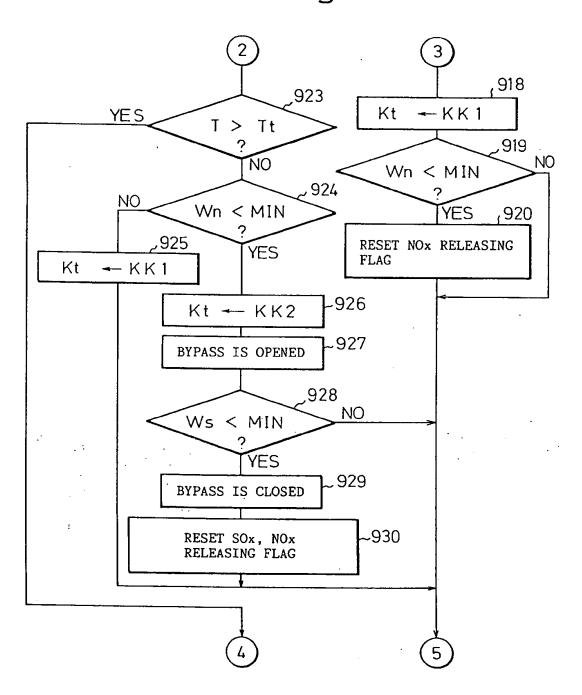


Fig.39D

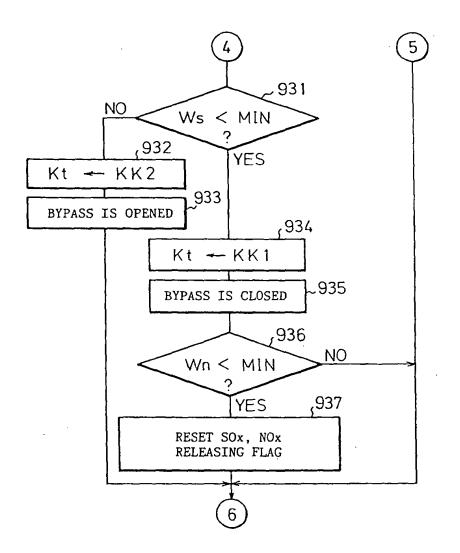


Fig. 39E

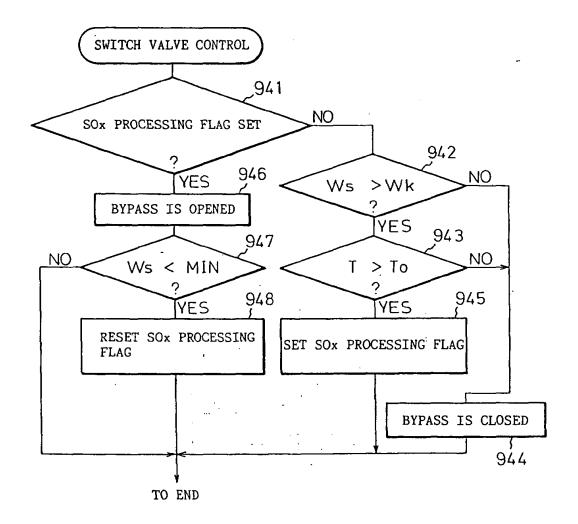
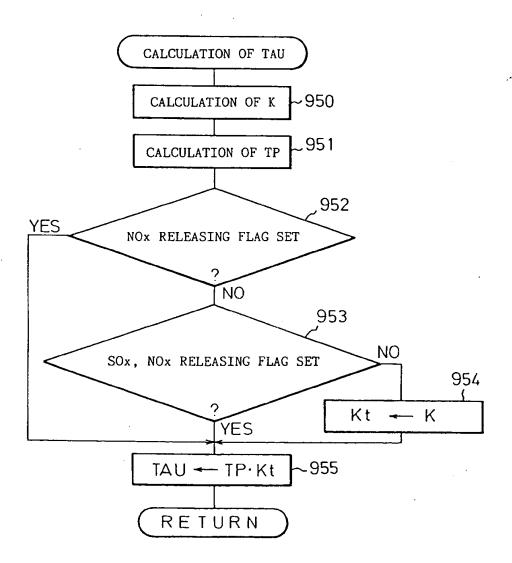


Fig. 40



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP93/01764 CLASSIFICATION OF SUBJECT MATTER Int. Cl⁵ F01N3/24 According to International Patent Classification (IPC) or to both national classification and IPC FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) Int. C1⁵ F01N3/24, F01N3/28, B01D53/34, B01J23/58, F02D41/02 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1926 - 1993 Kokai Jitsuyo Shinan Koho 1971 - 1993 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) C. DOCUMENTS CONSIDERED TO BE RELEVANT Citation of document, with indication, where appropriate, of the relevant passages Category* Relevant to claim No. PY JP, A, 5-76771 (Mazuda Motor Corp.), 1 - 37March 30, 1993 (30. 03. 93), Line 31, column 2 to line 10, column 5, (Family: none) Y JP, A, 2-149715 (Mazuda Motor Corp.), 1-37 June 8, 1990 (08. 06. 90), Lines 3 to 13, column 3, (Family: none) JP, B2, 1-56816 (Ebara-Infilco Co., Ltd.), Y 2 December 1, 1989 (01. 12. 89), Lines 3 to 26, column 3, (Family: none) JP, A, 64-30643 (Matsushita Electric Ind. Y 2 Co., Ltd.), February 1, 1989 (01. 02. 89), Line 5, column 4 to line 10; column 5, (Family: none) JP, A, 53-115687 (Matsushita Electric Ind. 2 Co., Ltd.), X Further documents are listed in the continuation of Box C. See patent family annex. Special categories of cited documents: later document published after the international filing date or priority date and not in conflict with the application but cited to understand "A" document defining the general state of the art which is not considered to be of particular relevance the principle or theory underlying the invention "E" earlier document but published on or after the international filing date "X" document of particular relevance; the claimed invention cannot be "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) considered novel or cannot be considered to involve an inventive step when the document is taken alone document of particular relevance; the claimed invention cannot be "O" document referring to an oral disclosure, use, exhibition or other considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "P" document published prior to the international filing date but later than the priority date claimed "&" document member of the same patent family Date of the actual completion of the international search Date of mailing of the international search report February 23, 1994 (23. 02. 94) March 8, 1994 (08. 03. 94) Name and mailing address of the ISA/ Authorized officer Japanese Patent Office

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP93/01764

tegory*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No
	October 9, 1978 (09. 10. 78), Line 4, column 1 to line 2, column 2 & DE, A1, 2811627 & FR, A1, 238367 & AU, A1, 3427378 & GB, A, 1573878 & AU, B2, 513201 & CA, A1, 1105240 & JP, B2, 57-27739 & FR, B1, 2383670 & DE, C2, 2811627	
Y	JP, A, 4-171215 (Toyota Motor Corp.), June 18, 1992 (18. 06. 92), Line 1, column 8 to line 8, column 9, (Family: none)	. 3
A	JP, A, 60-182325 (Toyota Motor Corp.), September 17, 1985 (17. 09. 85), Line 13, column 8 to line 7, column 9 & US, A, 4682577	8-22
A	JP, U, 62-126508 (Toyota Motor Corp.), August 11, 1987 (11. 08. 87), (Family: none)	23-26
A	JP, A, 3-124909 (Mitsubishi Motors Corp.), May 28, 1991 (28. 05. 91), Line 18, column 3 to line 11, column 4, (Family: none)	36, 37
Α	JP, A, 2-149714 (Mazuda Motor Corp.), June 8, 1990 (08. 06. 90), Line 15, column 3 to line 19, column 4, (Family: none)	36, 37

Form PCT/ISA/210 (continuation of second sheet) (July 1992)